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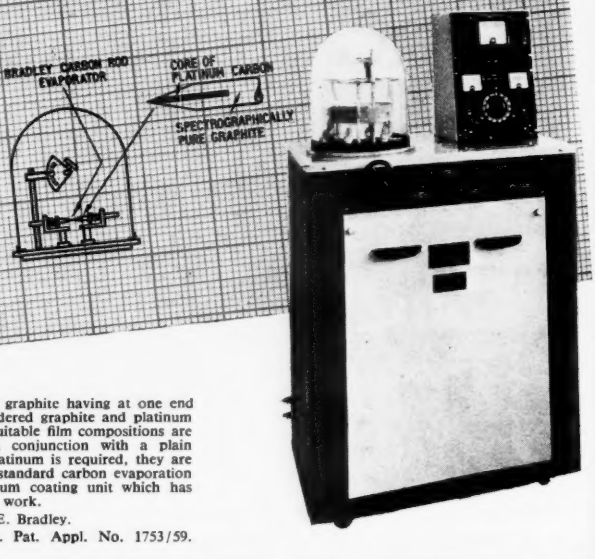

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THE STUDY OF MAN

DESPITE comments during recent years that the British Association for the Advancement of Science appeared to have lost both its bearings and its impetus, it has been generally acknowledged that the presidential address has always been much more than a rallying call at an annual meeting; it has increasingly come to be recognized as a statement by a leading man of science to the nation. In these addresses, each president has considered a theme which often has reflected outstanding interests of men of science at that particular time. In a discipline which daily grows more complex and bewildering, Sir Edward Appleton at Liverpool pleaded with men of science to make themselves intelligible to the layman; without an informed populace he showed that science could not flourish. At the Dublin meeting, Prof. P. M. S. Blackett was concerned with the need for applying science and technology on a world-wide front to solve world-wide problems of poverty and distribution. With his own travels as background, Prince Philip at Edinburgh discussed international aspects of science and how they could contribute to better understanding between peoples everywhere. Now, in a world where powerful blocs have realized that material strength alone is not enough, this year's president, Sir James Gray, invites men of science everywhere to pay full regard to moral principles and the social repercussions of their discoveries (see p. 35 of this issue).

The address is noteworthy for a number of features. First, because Sir James Gray has looked at science as a whole and has supported his arguments by evidence drawn from a number of the sections which comprise the British Association; he himself has acted as a link between them. Secondly, because he has used the life-science of biology to show its unifying influence in the overall study of man and, thirdly, because he has used his own wide background to examine defects in the educational system before making suggestions both for spreading and applying knowledge of science and technology throughout the world and for making it part of the general philosophy of man. Like others in this famous series, his address will be long remembered as a contribution to man's general evolutionary progress.

Two of Sir James's general topics will command widespread support. The ever-present need to consider the beneficial effects of science on international relationships is made very difficult in a world where science is primarily seen as a manufacturer and distributor of hydrogen bombs; Sir James is emphatic that the primary objective of men of science should be to illuminate the beauty of science, its inflexible pursuit of truth, its challenge to courage and tenacity and its power to inspire.

The place of science in a general philosophy of life is equally well put. Like music, science knows no barriers, and the combined efforts of scientists throughout the world are necessary if man is to continue in his efforts to unravel the secrets of Nature. Where there are political restraints, where knowledge is bounded materially and mentally by local and national barriers, the man of science can provide a bridge which should encompass the Earth. Missiles should be guided, not to destroy mankind, but to bring fresh delight in making clearer the mysteries of the heavens.

To make wise and humane use of science, as Sir James rightly points out, something more than statistics or the precise laws of physics and chemistry will be required. The challenge is to the less well-defined biological sciences and to the ill-defined social sciences arising from them. These sciences must be vigorously pursued not only to discover more of man himself, but also of his relationships with his fellows everywhere; they must also be more widely taught so that more and more people have better opportunities for understanding themselves and other people. Sir James is right to emphasize that it is in the biological and social sciences that the answer may be found as to whether or not science has real cultural significance. In his address, the new president of the British Association also shows the practical nature of the biological sciences, and that man still has much to learn from his evolutionary predecessors. Students of aeronautics, navigation and communications would hasten further discoveries if they paid more attention to biology. It could be added that many students of the humanities and of the physical sciences could considerably reduce the cost of the National Health Service if they would but study some of the general principles of biology; in so doing they would improve their health and, presumably, their happiness.

In the field of demography, Sir James uses his own arguments to give full support to conclusions put forward by Prof. Blackett in Dublin. With evidence drawn from the study of natural evolution, he clearly and courageously puts his choice before all civilized beings. Accepting the discipline of voluntary limitation of families, man can direct the course of his own evolution without the evil consequences of over-population; if he "behaves like an animal and allows his population to increase while each nation steadily increases the complexity and range of its environment, Nature will take her course and the law of the jungle will prevail". Churches throughout the world should examine their doctrines to see whether they are spiritually justified in bringing misery and destitution to so many people, and whether they are indeed helping man to achieve the highest moral and spiritual development of which he is capable. Men, Sir James says, really ought to be able to do something better than ants.

In another comparison of man and animals, Sir James again shows the practical advantages which deeper study of the biological sciences could bring. Study of the learning process has revealed five basic principles, all of which could be applied to the training of human beings. These principles could be made

much more use of by teachers everywhere and could revolutionize existing training methods in industry; adoption of these principles could so influence productivity that the well-being of many under-privileged peoples could be improved. The all-too-prevalent rule-of-thumb methods used to control industry, which were described by Sir Alexander Fleck at Glasgow last year, would quickly disappear if Sir James Gray's biological principles were widely adopted in education and training.

From his own education and experience, Sir James treads a well-worn path in pleading for a wider outlook in the teaching of science. Where the majority of children are still leaving school without any real acquaintance with science, it is right that the president of the British Association should support his predecessors in advocating the teaching of science to more children more often. Adults, too, should not be neglected, and much responsibility rests on existing and projected area organizations of the British Association. In those areas where they have already gone to work they have taken on their tasks with enthusiasm and energy. They can do much to support their president and to make the British Association once more regarded not only as an organization which holds an annual meeting, but also as the spearhead for spreading interest in science throughout Great Britain. In so doing they can also help the British people to understand more deeply the meaning of democracy and to accept the responsibilities it brings.

THE IMPORTANCE OF BEING HUMAN

The Importance of Being Human

Some Aspects of the Christian Doctrine of Man. By E. L. Mascall. Pp. vii+118. (London: Oxford University Press, 1959.) 10*s*. 6*d*.

A BOOK on the Christian doctrine of man in the light of modern science can at least be said to have a subject of vital concern to all who care for religion. Though Dr. Mascall has not written a comprehensive treatise, he has dealt with some of the fundamental questions, and it need not be added that he is well equipped both by his knowledge of science and his theological learning for the task.

There are two kinds of book on this topic, one that is prepared to modify or 're-interpret' the Christian dogmas and the other that defends them with no accommodation to modern thought. Dr. Mascall's book belongs to the latter class. Though, of course, he is ready to restate the doctrine of the Church to make it more intelligible, he will not contemplate any radical revision. He writes as one who accepts an Aristotelian metaphysic, in the main according to the theistic version of St. Thomas, and regards the tradition of the Christian Church as revealed truth. It is to be hoped, however, that these presuppositions will not deter readers from attending to what he has to say, for he touches on problems that need to be faced. The modern man's difficulty about understanding his nature and status in the universe, Dr. Mascall thinks, is largely due to the fact that science appears to allow him no "special and assigned status" and no "definite and determined nature". Scientific discourses on the uniqueness of man really leave the ordinary man in the dilemma that he does not have any clear idea of what being human means. He was better off in this respect when he could be satisfied with the assurance that man is the "rational animal". Dr. Mascall rejects the suggestion that man may be a stage in the evolution of some higher kind of being. The Incarnation, he holds, must prohibit any Christian from regarding man as a stepping-stone to some superman. "If the Christian religion is true, we have quite solid reasons for holding that, whatever developments man is meant to undergo, man is meant to remain man; for, if God has himself become man in the Incarnation, he has sealed human nature with a certificate of value whose validity cannot be disputed". I think this quotation gives the keynote of the book. It leads on to discussions of "Body and Soul", "Individual and Society", "Nature and Supernature", "Man Fallen and Man in Christ", all of which are characterized by shrewd insights and an uncompromising adherence to traditional Christian doctrine. A particularly interesting and important point is elaborated in the chapter on "Nature and Supernature", where Dr. Mascall develops the conception of "the fundamental openness of man's being to God's activity" as the basis of "the Catholic doctrine of the elevation of man's nature to the level of supernature by grace".

Much in this book will seem to scientific humanists strange and unacceptable, but they may learn something from it and in any event there is æsthetic pleasure in reading a thesis clearly stated and ably argued.

W. R. Matthews

T. H. HUXLEY

T. H. Huxley

Scientist, Humanist and Educator. By Dr. Cyril Bibby. Pp. xxii+330+13 plates. (London: C. A. Watts and Co., Ltd., 1959.) 25*s*. net.

TOO many people remember T. H. Huxley simply as 'Darwin's bull-dog'. The occasion of dramatic reproof to an ill-mannered and ignorant bishop is a single incident that obscures a life of energy and devotion in many fields; and Dr. Bibby's book, painstaking though it is, does not really succeed in communicating the excitement of the intellectual battlefields over which its hero fought. Partly this is due to its arrangement. The author has discarded a straightforward biographical treatment in favour of one in which separate sections deal with particular aspects of Huxley's interests. The result is to dehumanize the central character, to make him less a vivid and warm personality than a mouthpiece for sentiments that leave an impression of worthiness rather than intensity. But the cause of this flatness is not primarily Dr. Bibby's fault; it is simply that much of what Huxley thought and said is no longer a daring adventure of ideas. His reputation has suffered by his own success. He appears less exciting to us than he did to his contemporaries because many of the battles which he fought with such vigour have now been won. The biological views which he supported are in modified forms part of the accepted fabric of our thought. The aim of an adequate provision of scientific education, or indeed of adequate and universal education of any kind, which he spent

himself in promoting is now, if not achieved, at any rate acknowledged as a necessity for a civilized community; and at a deeper level the scientific and rational attitude which was the mainspring of his life and work is nominally at least part of the intellectual climate of our time.

But it would be a very superficial view of Huxley that dismissed him as a thinker from whom we have nothing to learn. Huxley was a man who was very characteristic of his time; it can truly be said that he embodied those qualities of the Victorian Age which we can most envy and most admire. It was an age of principles and of beliefs, and Huxley himself believed passionately in the value of human reason, in the power of education to transform societies, and in the power of science to change not only man's environment but also his habits of thought. He was a Victorian of the same mould as Thomas Arnold and George Eliot. To the causes in which he believed he sacrificed his own scientific achievement, and it is an interesting speculation as one reads this book to ask whether or not Huxley was right to leave undone the original work he might have carried out in the laboratory and instead spend endless hours in committees, on the London School Board or in writing controversial articles. For him education, science and greater social equality were causes to be fought for with incredible industry, with the resources of a superb gift of writing, and with a pervading moral earnestness. If one adds to these no little ability in the art of wire-pulling for good causes one can understand why he attained an influence over the thought of his time that few men have had.

By comparison our own age seems half-hearted and disillusioned. Two great wars have shown us that a civilization highly developed in science and technology is still capable of behaving as irrationally and cruelly as a band of savages. One of Huxley's own gifted grandsons has revealed the kind of Utopia to which scientific progress can conceivably lead. We have lost the certainties and the simplicities of the Victorians, and it would no longer seem worth while for an eminent man of science to conduct a controversy with a prime minister on the credibility of the story of the Gadarene swine. The irrationalities of our time are more pervasive and infinitely more harmful than those against which Huxley fought. But if Huxley's beliefs seem in some ways over-simple, his vigour, his humanity, his belief that the scientist must show concern for the social and intellectual problems of his time, offer us a great example. Huxley stands as evidence of the fact that a scientist can also be a humanist and an educator, and Dr. Bibby deserves our gratitude for making clear this triple contribution at a time when some such synthesis is so necessary.

JAMES OF RUSHOLME

STARS AND MEN

Of Stars and Men

The Human Response to an Expanding Universe By Harlow Shapley. Pp. vii+145. (London: Elek Books, Ltd., 1958.) 15*s*. net.

DR. HARLOW SHAPLEY, director of the Harvard College Observatory for more than thirty years, is a world-renowned figure in the fields of astronomy and cosmography. He has the not common gift of being able to write simply and lucidly for both scientist and layman. Dr. Shapley begins by attempting an obituary of the anthropocentric view that man is the centre of the cosmos, and continues by interpreting the consequences to man (or rather to certain aspects of rational thinking) of the latest scientific discoveries in the cosmos. Dr. Shapley's interpretation of man's position in the cosmos—a favourite theme since the writing of the first chapter of Genesis—is the latest and the best to date, but it will not prove to be the last. No doubt Dr. Shapley deduces from our cosmological knowledge the best interpretation of our present generalizations, but only from the physical point of view. It is difficult to know how terrestrial man can ever do more than speculate on the existence of life on planets outside his own solar system. Interesting as all this is as a rational and speculative exercise, much of the issue is evaded. The nature of man as a spiritual being capable of high aspirations, of self-sacrifice, and the creation and appreciation of beautiful things, does not appear in Dr. Shapley's picture to any great extent. This is not to belittle this book; within the framework which he honestly sets out at the beginning he has developed his story with logic, restraint and charm, but few people will think that it is the whole story.

Dr. Shapley's displacement of human life from its once supreme position does not make him a pessimist, for he argues cogently that there must be at least a hundred million planets capable of supporting some form of life. Dr. Shapley concludes his book with what he calls "a Martian look" into the future. He dismisses the prospect of the Earth's collision with a star, or of wandering from its orbit and getting too near or too far away from the Sun. Nor does he envisage a biological calamity wiping out the whole human race. The real danger is man himself, who is busy perfecting the tools for performing an operation which is unlikely to be performed by natural forces.

"Fish or *Homo*, that is the question. Which animal type will most certainly be here 10,000 years from now, and which will more likely fall the victim of fate and folly? The answer, of course, is too obvious. The fish have been here several hundred million years; man but a few thousand. . . . But 10,000 years is a pretty long time for *Homo*. His structure and social manners do not make him a good insurance risk."

Much humanism is a weariness of the flesh and in the making of cosmologies there is no end, but Dr. Shapley avoids these pitfalls and has written a book which should stimulate and challenge every intelligent reader.

W. L. SUMNER

ASTROPHYSICS

Handbuch der Physik

Herausgegeben von S. Flügge. Band 50: Astrophysik 1: Sternoberflächen-Doppelsterne. Pp. vii+458. (Berlin: Springer-Verlag, 1958.) 98 D.M.

THIS is the first of the five volumes of the new "Handbuch der Physik" which are to be devoted to astrophysics. Preliminary announcements show that a wide range of subjects is to be covered, excluding solar physics but including some of the most recent developments in other fields. However, the contributions in this particular volume deal mostly with the older parts of astrophysics, based on

techniques well established before 1940. But they are none the worse for that; indeed, it is one of the weaknesses of present-day astrophysics that insufficient effort is being put into basic measurements such as are dealt with in several of these articles; for example, stellar masses and radii from visual and eclipsing binaries, atomic abundances from stellar spectra.

Ch. Fehrenbach has given a full account of the classification of normal stellar spectra. P. C. Keenan has written briefly of stars with peculiar spectra, in a useful although not comprehensive article which contains material not readily obtainable elsewhere, for example, on high-velocity stars. P. Swings's contribution on molecular bands in stellar spectra deals with a complicated subject in which much remains to be done and in which there is a scarcity of other publications. Two useful contributions by K. Wurm on planetary nebulae are widely separated in the book, although intended to complement each other. I find it difficult to understand why they were not united. J. L. Greenstein has written an important original paper on white dwarf spectra which is essential reading for anyone working in this field.

P. van de Kamp's article on visual binaries is to be commended. It deals with a woefully neglected subject on which there is no modern text-book. There follow accounts of eclipsing binaries by S. Gaposchkin and of spectroscopic binaries by O. Struve and Su-Shu Huang. Eclipsing binaries are usually also spectroscopic binaries; both classes are very important sources of data for checking theoretical models, but the complications shown by their light curves and spectra have led to speculative ideas for which we have as yet no adequate check.

The article by D. Barbier is virtually a short text-book, giving a good systematic exposition of what may be called the conventional theory of stellar atmospheres and its very solid achievements.

The articles are in English, French or German. Each includes a brief general bibliography, in some cases with short comments. Adequate attention has been given to other references also. The index is in three parts: German with an English translation, English with a German translation, and French only for the three articles written in French.

As in every "Handbuch" of this character, the contributions vary a great deal in merit; the better ones are excellent. Present indications are that this is to be one of the cheaper volumes, although its price is more than £8.

R. O. Redman

ELECTRONICS IN BIOLOGY

Electronic Apparatus for Biological Research

By P. E. K. Donaldson. With contributions by Dr. J. W. L. Beament, F. W. Campbell, Dr. D. W. Kennard, Dr. R. D. Keynes, Dr. K. E. Machin and Dr. I. A. Silver. Pp. xii+718. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 120*s*.; 20 dollars.

To be able to use and interpret correctly the results obtained by using electronic apparatus, the biologist requires some understanding of electronics—a secondary subject which may have little direct appeal to him—and for this reason, a book explaining concisely the principles and functions of electronic apparatus used in biological research could be of great value. The author of the book has had the needs of the biologist primarily in mind and he and his associate comtributors, as members of the staff of the Department of Physiology at Cambridge, ought to be well qualified to look after his needs.

The book is divided into four parts: Part 1, principles of electronics (277 pp.); Part 2, practical use of components (48 pp.); Part 3, articles by specialist contributors on transducers, electrodes, indicators and measurement of temperature, light and radioactivity (249 pp.); Part 4, complete apparatus (127 pp.). The first part is of standard text-book form, with the exclusion of subjects considered to be of little interest to the biologist. The treatment is brief, and in some cases, unfortunately, it is insufficient to permit one to follow applications which are given later. The section on filters is too detailed for the reader wishing to be acquainted with, rather than fully to understand, the subject. On the other hand, the application of the valve as a switching element is covered very briefly, and no mention is made of the pulse response of networks with reference to differentiation and integration. The various sources of noise are analysed, this chapter being particularly useful in quoting orders of magnitude. The graphs here are excellent and self-explanatory but could have been more conveniently placed in relation to the text, as has been done elsewhere. In separating the information on batteries in Part 2 from the section dealing with stabilized power supplies, the opportunity to discuss their relative merits is missed.

There are nine chapters in Part 3 dealing with specific subjects, all of which should prove useful to anyone concerned with biological instrumentation. The theoretical treatment of light sources and detectors is well done, as also is the assay of radioactivity, but circuit applications would have improved both chapters. The articles on electrodes, transducers and the use of relay circuits are valuable contributions, but that on temperature measurement could have been improved by a recapitulation of the physical principles.

The important section of Part 4 dealing with apparatus is unfortunately condensed into only one-sixth of the book. Stimulus artefact is explained very well, as is also the subject of interference, and all readers interested in design would benefit from the author's design procedure. A chapter on transistors gives a useful introduction to the principles, but an assessment of their possible future in biological research would have helped to define their importance.

The book is well written, and the practical advice given shows that the author writes from experience. Its value could have been increased by linking the biological specifications to appropriate designs, an important feature of biological instrumentation. The failure to achieve this linkage makes the book of rather limited value to the engineer who is designing apparatus for biologists. However, in helping to satisfy the requirements of the physiologist, the aim of the author has been achieved, albeit at a high price. In the preface the author expresses doubts about the suitability of the title, and since the emphasis is so much on physiological applications, the reviewer is of the opinion that "Electronic Apparatus for Physiological Research" would convey more precisely the nature of the subject-matter.

W. J. Perkins

HISTORY OF TECHNOLOGY

A History of Technology

Edited by Charles Singer, E. J. Holmyard, A. R. Hall and Trevor I. Williams. Assisted by Y. Peel, J. R. Petty and M. Reeve. Vol. 5: The Late Nineteenth Century, *c.* 1850 to *c.* 1900. Pp. xxxviii + 888 + 44 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 168*s.* net.

THIS fifth volume of the "History of Technology", covering the approximate period 1850–1900, marks the conclusion of this great work, which traces the development of technology from the earliest times to the beginning of the present century. In some fields brief reference is made in the present volume to developments that have taken place so recently as the years following the Second World War.

The book is divided into eight parts. The first deals with primary production, including the management of food and the development of the metal and petroleum industries. The second part concerns itself with stationary and marine steam engines and the internal combustion engine. Part 3 treats of the rise of the electrical industry; Part 4 of the chemical industry. Part 5 deals with transport, including railways, ships, aircraft, road vehicles, and cartography and other aids to navigation. Part 6 is concerned with civil engineering, and covers building materials, bridges, tunnels, hydraulic engineering and water supplies. The seventh part discusses manufacturing in general, including textiles, metals, machine tools, ceramics, glass, printing, photography, and rubber. The last part evaluates technological education and the general role of technology and its social consequences in the modern world.

Each of the chapters is written by a competent authority, and the whole volume has been brought together and made into a unified work by its principal editor, the eminent Dr. Charles Singer, and by Dr. E. J. Holmyard and two other distinguished co-editors.

Although it could not be expected that every one of the thirty-four chapters would delve with equal thoroughness into the mass of technological history behind each subject treated, nevertheless, the whole presents a most enlightening and valuable summary of progress during the crucial last half of the nineteenth century. For example, two such different stories as the development of machines for the generation of electricity and the discovery of aniline dyes are almost breath-taking in their implications for later pure science as well as for technology.

It is certain that many full reviews of this extensive and admirable work will be written in Great Britain. The present American reviewer feels that he should devote special attention to the volume as it may appear to some American eyes. First of all, it is impossible not to be struck by the clarity of exposition of the present work. It is hard to believe that an equal number of American students in this field could be found who could write so well. It is indeed surprising to find authorities in the highly specialized fields of technology who are able to present their subjects so lucidly. The style of the volume will make it attractive even to the layman who is concerned with the full history of our age. Anyone who is interested in reading present-day political or social history will also enjoy the style and the content of this volume. Here the reader is not overwhelmed by mathematics or repelled by an unnecessarily technical vocabulary. It has been possible for the editors to cover the really vast human achievement that is considered in this book only by exercising great verbal restraint. Often a single sentence summarizes a large development that even in an encyclopædia article might have been given a long paragraph. For example, Josiah Willard Gibbs, considered by some to be the man who did most for pure science underlying technology in America during this period, is described in four words as the formulator of the phase rule.

I could not indeed read many pages of this book without thinking of the fascinating problem of national differences in the approach to scientific and technological history. In recent years the world has noted successive Russian claims that very many of the great inventions and developments of the past really originated in Russia. Similarly, one who walks through the Deutsches Museum in Munich must feel that the tens of thousands of earnest young Germans who go through its admirable halls each year must gain the impression that the full flowering of the industrial revolution took place almost alone in fertile German soil. It is similarly apparent that the present volume quite properly emphasizes British science, technological inventions and developments. This very fact makes the work especially valuable in America. Many new industrial developments in the United States grew out of British beginnings, and this volume clearly portrays this essential background.

Some day a general treatise on detailed technological developments in the United States will be prepared, and when it does appear, it will be a valuable supplement to the present volume. When such a treatise is written, it will, for example, give full emphasis to the material contained in the voluminous publications of such organizations as Benjamin Franklin's still very active, learned academy, "The American Philosophical Society, Held at Philadelphia for the Promotion of Useful Knowledge"; the National Academy of Sciences of the United States; and the Smithsonian Institution. It is indeed a little surprising to find no reference in the index to these American organizations, which were doing so much for world science and technology during this period, in spite of many references to the Royal Society, Royal Institution, and the Science Museum, South Kensington. It is quite understandable, however, that the mass of American material could not be dealt with in a complete way in the present book, which is very properly British in its central emphasis.

All five volumes of this great work, nevertheless, fill a need long and keenly recognized, especially, it may be, on the western side of the Atlantic. Americans will long be deeply conscious, therefore, of the debt that they owe to the distinguished authors and editors of all five volumes of the work. The book will be read with pleasure and satisfaction by everyone in the United States who is professionally concerned with the history of technology and, as already suggested, by many others as well. In the years ahead these volumes will be among the reference books most frequently reached for on the working shelf of any student who is concerned with this area of scholarship. An expression of gratitude is also due to the great Imperial Chemical Industries, Ltd., which helped to make possible the preparation of these expensive, well-illustrated, and well-printed volumes.

LEONARD CARMICHAEL

THE WISTAR INSTITUTE OF ANATOMY AND BIOLOGY, PHILADELPHIA

By Dr. R. E. BILLINGHAM and Dr. H. KOPROWSKI (Director)

NO institute is more deeply rooted in the history of American biology and medical science than the Wistar Institute of Anatomy and Biology of Philadelphia (Fig. 1). Its opening in 1894 was made possible by the generosity of General Isaac J. Wistar, a colourful figure in American history—sometime farm-worker, trapper, lawyer, company president and Union Army general. Its primary purpose was to house a fine collection of anatomical specimens and preparations in the Hunterian tradition amassed, in part, over the years by General Wistar's great-uncle, Prof. Caspar Wistar, doctor of medicine of the University of Edinburgh, professor of anatomy at the University of Pennsylvania, and in 1811 author of "System of Anatomy", the first and for long the standard anatomical text in America. The other distinguished contributor to this collection was Dr. W. E. Horner, who was at one time dissector to Wistar and who later occupied the chair of anatomy.

In addition to its museum, the Institute was equipped with laboratories and facilities to enable investigators to study comparative anatomy and experimental biology. In 1923, a complete printing press organization was established on the premises so that the Institute could exert more efficient control over the well-known journals and publications bearing its imprint, some dating from 1908. The intensive investigation of the laboratory rat has been almost a Wistar prerogative for nearly half a century; indeed the albino rats from its large animal colony have probably propagated the name of the Wistar Institute throughout the world almost as effectively as its journals.

Probably because of the changing emphasis in biological and medical research, the Institute's facilities became no longer adequate to attract those investigators who wished to work in the forefront of biological science, and its scientific contributions declined sadly. In 1957, however, the Board of Managers appointed Dr. Hilary Koprowski, a virologist, as director. In the ensuing months, grants from the Federal Government, private enterprise and personal donations have been spent in modernizing the Institute in all respects and enlarging its scientific staff to its present level of fifty, which includes representatives of seven different nations.

According to its statute book "The Institute will be open to any and every searcher for knowledge", and at present it has eight graduate research students who are enrolled at the University of Pennsylvania, which lies immediately across the street and in which several members of the staff hold academic appointments. There are Wistar professors of microbiology, of research medicine and of zoology, and some associate and assistant professors. Indeed, the loose affiliation between the Institute and the University of Pennsylvania is ideal for both organizations. According to its deed of trust "the object of the laboratories and workrooms and of any lectures or instruction to be given at the Institute shall be for the improvement and research of postgraduate or advanced students and of searchers after new and original knowledge, and neither the Institute, its premises or property shall be used to replace or supersede such elementary instruction of undergraduate students as now does, or hereafter may fairly pertain to the ordinary or necessary curriculum of the University".

To commemorate the recent completion of the Institute's re-organization a symposium on "The Structure of Science" was held during April 17–18, and attended by more than five hundred biologists. The subject of the first session was "National and International Research". The opening speaker, Mr. Francis Boyer, president of Wistar's Board of Managers, stressed the important role still open for small, independent research institutes in contemporary science. The Hon. Lister Hill, United States Senator from Alabama, gave an account of the Bill which he recently introduced in Congress to create a National Institute of International Medical Research, as part of the National Institutes of Health. This would be charged with the support of medical projects submitted by competent investigators from any part of the world. Other speakers were Dr. Leroy Burney, surgeon general, United States Public Health Service, who emphasized the extremely liberal conditions under which federal grants were made to research institutes such as Wistar, and Dr. Detlev Bronk, president of the Rockefeller Institute and the National Academy of Sciences, who spoke of the importance of allowing investigators complete freedom of action in a world that is constantly clamouring for direction of research. Finally, Dr. Tuzo Wilson, professor of geophysics, University of Toronto, gave an illustrated account of his recent visit to "mainland" China and Formosa. He said that the mainland Chinese were the hardest working people he had ever seen. If their geophysical laboratories are a measure of their activity in other disciplines, it would not be long before they contributed fully to world science.

The following session, subtitled "The Road to Knowledge", was opened by a paper on mathematical principles in biology by Dr. Nicolas Rashevsky of the University of Chicago. He said that hitherto it was only in genetics that mathematical biology had achieved a definite predictory and explanatory value. After outlining the difficulties of attempting to apply or develop theoretical biology to explain organic form or complexity of organization—analytical geometry cannot take into account such a trivial event as a cat changing its posture—he outlined a "principle of optimal design", according to which the overall design is compatible with the highest degree of economy for a given set of physiological functions. This concept had already been applied successfully to the design of the vascular system. Dr. Rashevsky then discussed the relationships between physico-chemical processes underlying super-

Fig. 1. The Wistar Institute of Anatomy and Biology, Philadelphia. The building, completely renovated in 1958–59, now houses new laboratories and equipment for its staff of fifty scientists

ficially comparable events in higher and lower organisms, and argued that despite their greater repertoire the biological processes of higher organisms were interpretable in terms of the fewer properties of simpler organisms. He predicted that a unicellular organism will be found capable of producing antibodies to some specific antigens.

Dr. Ludwig von Bertalanffy, Sloan visiting professor at the Menninger Clinic Foundation, discussed the role of theoretical biology in integrative sciences. He stressed the inadequacy of the mechanistic approach derived from classical physics, which had as its goal the resolution of living things into component parts and processes, by analogy with machines. In the new philosophy the organism was no longer to be considered as being simply a reactive system, answering stimuli of extraneous origin in order to re-establish some sort of equilibrium. In Bertalanffy's own words, "the problems of organic wholeness, organization, teleology, and the like, which were taboo in the mechanistic world picture, are now taken seriously and approached as legitimate problems for scientific inquiry and theory".

Dr. Anatol Rapoport, professor of mental health, University of Michigan, in a witty and lucid consideration of the language of science, said that although most advanced branches of science had developed their own special languages, such as the molecular structural symbolism of chemistry, there was still a residue of "ordinary" language—its vernacular component. With particular reference to chemistry and physics, he argued that the language of science neither depended upon an extensive vocabulary nor was necessarily devoid of poetry. Key terms in higher algebra included 'group', 'ideal', 'trace', and fundamental words in physics were likewise simple—for example, 'field', 'orbit', 'nucleus'—yet it was impossible to explain the meaning of any of these words to anyone lacking considerable experience of the appropriate kind. In the language of science, very simple words were used to denote exceedingly complex concepts. Most of the terms in physics were defined by mathematical operations, for example, 'feet per second squared', in contrast to classical terminology which was translatable into visual images. This far-reaching innovation freed the intellect from dependence on literal conceptions and mathematical operations had largely taken their place.

Dr. Rapoport denied that the language of science was prosaic. It has its own metaphors: the 'osculating curve' (not an amatory function, but a mathematical form), the engineer's 'black box', the neurophysiologist's 'threshold', and the mathematician's 'primitive'. In conclusion, he brought up a most profound question of scientific philosophy—the metaphysical underpinnings of the language of science: Where was the borderline between knowledge and faith?

The last speaker of the session, Dr. Donald H. Andrews, B. N. Baker professor of organic chemistry in Johns Hopkins University, discussed new relationships between art and sciences. He developed an interesting idea on the analysis of form in terms of thermodynamics and entropy on one hand, and of information theory on the other. Citing as an example an unstruck piano string vibrating with overtones set up by its thermal energy, Dr. Andrews argued that a statue of marble probably had overtones "which in the harmonic realm are the exact equivalent, homomorphic with the space form". If this statue were cooled to within perhaps a 200,000th of a degree of absolute zero and its heat capacity measured and integrated as it was warmed very slowly, the entropy term would be obtained over the very lowest part of the temperature-range and would bear a direct relationship to the shape of the statue, based on the longest thermal vibrations, with wave-length a function of the shape of the statue.

In theory it should be possible to transmit 'space-form' information defining the statue over a distance via radio waves or telephone signals for reproduction at an appropriate lathe-assembly. Developing such new concepts of 'scientific æsthetics', Dr. Andrews concluded that perhaps a more faithful algebra of form was needed for many of to-day's problems, in thermodynamics, in the study of molecules and of molecular aggregates.

The speakers at the third session of the symposium concerned themselves with unifying principles in their respective fields.

Prof. P. B. Medawar, professor of zoology, University College, London, presented a critical account of the various possible theories which might account for the phenomenon of immunological tolerance—the specific immunological unresponsiveness induced by exposure of very young animals to antigens. After making two assumptions: (1) that the maintenance of the tolerant state depends on persistence of the antigen, and (2) that any one antibody-forming cell (and its descendant clone) responds to only one antigen at a time, he considered, in turn, a series of mutually exclusive postulates, for example, that immature antibody-forming cells capable of being made tolerant occurred (*a*) only in embryos or very young animals, or (*b*) in adults as well. He then went on to discuss the hypotheses one could arrive at by various combinations of postulates, one of which led logically to the view that while some cells in the adult became immunized by exposure to antigen, others must become tolerant.

Dr. Francis H. C. Crick, Cavendish Laboratory, University of Cambridge, spoke on the structure of viruses. He emphasized the multiplicity of factors which govern the aggregation or packing of identical units into a given space. In the simplest case, spherical sub-units are aggregated so as to occupy the smallest possible space. Such an array has certain elements of cubic symmetry. There are five-fold, three-fold and two-fold axes of symmetry. The surfaces of many viruses are polygonal with elements of 2-3, 4-3-2 and 5-3-2 symmetry; in some of these evidence has been obtained of a regular array of sub-units. Apparently, the protein parts of many viruses are made up of roughly spherical sub-units assembled in such a manner as to occupy the least space.

Studies on infectious ribonucleic acid isolated from tobacco mosaic and certain mammalian viruses ndicate, according to Dr. Crick, that the ribonucleic ɔid carries, at least in part, the necessary information to determine the amino-acid sequence of the protein sheath of the virus particle. However, since there are no known viruses consisting of less than 70 per cent protein, it is unlikely that the viral nucleic acid carries sufficient genetic information to determine such a large protein shell. The alternative is a large number of small, symmetrically packed, protein sub-units.

Dr. H. Gobind Khorana, University of British Columbia, showed how advances in our knowledge of organic chemical structures and of organic synthesis had contributed to an understanding of biological processes. He reviewed some of the important accomplishments in protein and peptide chemistry—such as the elucidation of the structure of gramicidin *S* and of oxytocic hormones. The determination of the total sequence of structural units in adreno-corticotrophic hormones and other biologically active materials should soon extend to the sequence in larger molecules such as ribonucleases.

Turning to research on intermediary metabolism, Dr. Khorana discussed the organic chemistry of phosphate esters, with particular emphasis on nucleotide co-enzymes, mentioning his own important work on the synthesis of co-enzyme *A*. He said that despite the underlying similarity in the structure of nucleotide co-enzymes, it was at present inexplicable and rather exciting that their specificity depends upon the nucleosides that they carry.

On another topic, the sequential analysis of nucleic acids, he emphasized the present need for research. He described the chemical synthesis of a number of oligonucleotides that would be useful in developing enzymatic degradation methods for structural analysis of nucleic acids. One problem which confronted us to-day, he concluded, was to match the sequential analyses of nucleic acids with similar analyses of amino-acids in proteins and polypeptides.

A lucid discussion of the mechanism of gene-action was presented by Dr. John R. Preer, University of Pennsylvania. He said that genes act by influencing the properties of proteins, probably because they are the determinant forms of the templates (usually held to be of ribonucleic acid nature) which direct protein synthesis. He felt that the original Beadle hypothesis of one gene : one enzyme should be extended to include protein and template, so that one would have one gene : one template : one protein.

The many different strain-specific ciliary proteins of *Paramecium* are particularly advantageous materials for the study of gene-protein relations. Many different loci with multiple alleles are involved in the determination of these proteins. Genes at only a single locus affect each type of protein, and a locus determining one type of protein is without effect on any other locus. This complex situation is explicable on the template hypothesis. Studies on the genetic determination of different types of hæmoglobin in man, which usually differ with respect to a single amino-acid, had furnished beautiful support for gene-amino-acid determination.

Dr. George Klein, Karolinska Institutet, Stockholm, gave a lucid analysis of the evolution of tumour cell populations. The change from a normal to a malignant cell was usually the result of a series of successive qualitative steps, known as tumour progression. The various unit characteristics of tumours such as growth-rate, sensitivity to drugs, invasiveness, etc., did not all change together during progression, but re-assorted independently so that each tumour appeared to undergo an evolution of its

own, differing from other tumours on a combinatorial basis. The postulated unit characters were probably not interrelated, but were determined by different cellular mechanisms.

Dr. Klein discussed three of the many conceivable mechanisms which might account for progression: (1) the selection, by intrinsic or extrinsic factors, of new variant cell types differing from the original type with respect to one or more unit characters; (2) the loss of ability of cells to respond to homœostatic forces of the organism; and (3) automatic changes in cell population characteristics which might occur merely by virtue of an increase in the population and did not depend on cellular change. Like Lederberg, he felt that analysis of the mechanisms of progression should be modelled on techniques derived from microbial genetics.

The closing session of the symposium was devoted to papers presented by members of the scientific staff of the Wistar Institute.

Dr. Hilary Koprowski, director of the Institute, spoke of the staff as a group of independent thinkers of widely different backgrounds who approached their scientific problems in individualistic ways but worked together through an "intercommunicating system". The main object of research at the Wistar Institute, he said, was the study of cellular biology, or perhaps more accurately, "the study of the biological micro- and macro-cosmos and the attempt to bridge the gap between the two". He enlarged on this concept, saying that staff members were making quantitative studies at the cellular level and were attempting the difficult and hazardous task of applying knowledge about the cell to studies of the whole organism.

Dr. Angus F. Graham discussed general aspects of cell-virus relationships and the methodology of their analyses. He had been developing an *in vitro* virus-mammalian cell system in fluid suspension, by means of which it might be possible to investigate quantitative aspects of virus infection in a manner analogous to studies with the classic phage-bacteria system.

Dr. Eberhard Wecker presented evidence that the infectious ribonucleic acid which he extracted by the usual phenol technique at 4° C. from cells infected by eastern equine encephalomyelitis or western equine encephalomyelitis was not derived from the virus elementary bodies themselves but from a virus precursor which appeared in the infected cells before the mature virus particles. Although lipid-containing mature virus particles did not yield infectious ribonucleic acid on treatment with phenol at 4° C., Dr. Wecker reported a successful extraction at higher temperatures (40–50° C.). He concluded by indicating how ability to distinguish between the precursor of ribonucleic acid and the acid itself from mature virus particles might lead to a better understanding of the biosynthesis of viruses within cells.

Continuing the discussion of viral nucleic acids, Dr. John S. Colter outlined studies made in collaboration with Dr. Kay Ellem. By a modification of the classic Gierer and Schramm phenol extraction technique for ribonucleic acid, in which cells were disrupted in solutions of high instead of physiological ionic strength, the deoxyribonucleic acid was extracted in the aqueous phase, while the bulk of the ribonucleic acid was eliminated into the phenol phase. The final product was free from protein and ribonucleic acid, and the yield was quantitative.

By adding sodium desoxycholate, the recovery of infectious ribonucleic acid by Gierer and Schramm's phenol extraction method from Ehrlich ascites cells infected with Mengo or West Nile viruses was greatly improved—possibly even five-fold. A collateral study of the ribonucleases of normal and malignant murine tissues implicated the pancreas as the source of the enzyme. Because of the existence of a ribonuclease inhibitor the pattern of ribonuclease activity of ascites tumour cells differed markedly from that of a normal tissue. The possible role of the magnesium ion as an inactivator of ribonuclease activity was discussed.

Dr. Raymond A. Brown outlined the biophysical properties of the preparations of deoxyribonucleic acid isolated by Dr. Colter's new method. The molecular weight was four to five million, and its sedimentation constant and intrinsic viscosity values were lower than those usually quoted for deoxyribonucleic acid.

His own electron microscope studies led Dr. Brown to consider cellular ribonucleic acid to be made up of two types of molecules, both 42–43 A. in diameter but differing in length. There was suggestive evidence of a periodicity in the location of the phosphate groups along the axis of the rod. Each rod probably consisted of a tightly coiled single polynucleotide chain. At low ionic strength, the molecule uncoiled.

Dr. Vittorio Defendi discussed the virus-host cell relationships of two tumour-inducing viruses: the *RPL*-12 virus of the lymphomatosis tumour of chickens and the polyoma virus in hamsters. He described the necrotic and proliferative lesions of *RPL*-12 virus infection in tissue cultures, in chick embryos and in hatched chicks, emphasizing particularly the derangement of deoxyribonucleic acid metabolism which occurred during the infection.

He then outlined his findings on the pathogenesis of tumours arising in Syrian hamsters following their inoculation at birth with polyoma (parotid gland) virus. All the tumours were of identical histological type regardless of their location. Preliminary analysis of the infectability of newborn hamsters with the virus suggested that immunological tolerance is involved. For example, inoculation of newborn animals with the virus along with isologous adult lymphoid cells resulted in a greatly decreased proportion of tumour-bearing hamsters, and there was an amelioration of the course of the malignant disease in the minority of animals in which tumours did appear.

Drs. Rupert E. Billingham and Willys K. Silvers described their studies on the tissue transplantation antigen determined by a locus on the *Y* chromosome in male mice. This antigen was responsible for the rejection of male skin isografts by females in many inbred strains. Female mice of the *C*57 strain could be made tolerant of subsequent male isografts by inoculation with male cells as late as 17 days after birth, and tolerance in females could also be induced by means of cell-free antigenic extracts prepared from isogenic male tissues. Employing the principle of immunological tolerance they were able to show that all male mice, irrespective of their genetic constitution, possessed exactly the same *Y* chromosome antigen. This conclusion followed from the finding that *C*57 females injected at birth with cells from males of any other strain are invariably made tolerant of male skin isografts. A *Y*-chromosome antigen was also present in male rats, which preliminary results indicated was exactly the same as in the mouse.

Concluding the symposium, Prof. Sven Gard, Karolinska Institutet, Stockholm, and visiting member of the Wistar Institute (1958–59), gave

warning against the general tendency to over-estimate the potentialities of pure biochemistry. The activities of a living cell as seen under the microscope immediately dispelled any idea that it might be regarded as a bag of enzymes. The fine structure of the cell with its innumerable surfaces and membranes offered a clue to the fundamental question: "Why and how do reactions occur in the right place at the right time?" The multiplicity of interests disclosed by the staff members of the Wistar Institute, and its strong tradition for morphology should guarantee concentric attacks on essential biological problems.

THE AUSTRALIAN ACADEMY OF SCIENCE

ON May 6, the Governor-General of Australia, Field-Marshal Sir William Slim, opened the new building which houses the offices and conference chamber of the Australian Academy of Science. The establishment of the Academy was initiated by a group of Fellows of the Royal Society of London resident in Australia (*Nature*, 170, 549; 1952). With the help of other Australian scientific leaders, they set up a body which received a Royal Charter personally from Her Majesty Queen Elizabeth II during her Australian tour in 1954.

The Australian Academy of Science is the representative body of Australian scientists at the national level, with functions comparable with those of the Royal Society of London, which was itself represented at the opening, on May 6, by its senior vice-president, Sir Lindor Brown. The fellowship of the Academy now numbers eighty-seven and up to six new Fellows are elected each year. The president of the Academy since 1957 has been Sir John Eccles, professor of physiology in the Australian National University, Canberra; his predecessor was Sir Mark Oliphant, director of the Research School of Physics in the National University.

In outlining the history of the Academy, Sir John Eccles said that the need for a national scientific body of the highest standing led in 1919 to the formation of the Australian National Research Council, and thanks to the devoted efforts of its leaders, the Council gave most valuable service to Australia. Yet it would be generally agreed that it had failed to achieve the status that was required of a national body with such weighty responsibilities. Various efforts at internal reforms of the Council proved to be impracticable and a more radical proposal emerged from a conference on "Science in Australia" organized by the Australian National University in 1951. At this conference and in the subsequent discussions there was a fairly general agreement that an Academy of Science with much more restricted membership should replace the National Research Council. The Council's executive with great magnanimity agreed to its dissolution in order to make way for the new Academy. This was a fine act of self-sacrifice made in the belief that the new Academy would be better fitted to give leadership in the scientific development of Australia.

The new Academy chose to model itself closely on the Royal Society of London, so taking advantage of three centuries of wisdom. The Academy is also especially indebted to the Royal Society for help in its petitioning for the Royal Charter, and for the gift of a magnificent Signature Book that is a replica of the original Signature Book of the Royal Society.

From the very beginning it has been of prime importance to ensure that the highest standards were maintained in the election to the fellowship, and that it was truly representative of all aspects of pure and applied science. It could be claimed that it has retained the confidence of the general body of scientists in Australia.

The functions of the Academy are both national and international. At the national level there are certain general responsibilities in the fostering of science and in its publication. However, it is at the international level that the Academy has its principal opportunities and functions. First, it is the body representing Australia at all the international scientific unions as well as at the Pacific Science Congress and the Pan Indian Ocean Congress. Secondly, it undertakes international scientific tasks for Australia. The most notable has been the International Geophysical Year, the Academy being responsible for Australia's fine contribution. From the International Geophysical Year there have developed further important international activities in which again the Academy represents Australia. The Special Committee for Antarctic Research and the Committee for Space Research are of vital interest to Australia, and both have achieved a high status. The third meeting of the Special Committee for Antarctic Research was held in Canberra this year and was generally agreed to be very successful. Among other achievements was the inauguration of the International Antarctic Analysis Centre as an annex to the Bureau of Meteorology in Melbourne. Other international activities are the organization of specialist international scientific meetings in Australia. In August a specialist biochemical meeting on hæmatin enzymes was held at the Academy. It is a field in which Australia holds a high place, and many of the leaders in other countries went to Australia for the conference. Next year the Academy is arranging for an international conference on the chemistry of natural products, which will be held in Melbourne, Sydney and Canberra.

In all these national and international activities the Academy can count on the devoted service not only of its own fellowship but also of the other scientists of Australia. The aim is to select the scientists best fitted for these special purposes regardless of their affiliation with the Academy. On the Standing and National Committees of the Academy the Fellows are outnumbered, and often scientists who are not Fellows hold key positions.

There will be no relaxation of labour now that a centre for science has been established in Australia. It has fine symbolism with its geometrical form and its great restraint of line and décor. The Academy can now and in the future radiate its influence over Australia and the world and receive from the world for Australia. But every end is a new beginning; and the Academy is now planning to become as well a channel for benefactions for scientific purposes and so to exert its influence not only through expert committees and individually by its Fellows but also

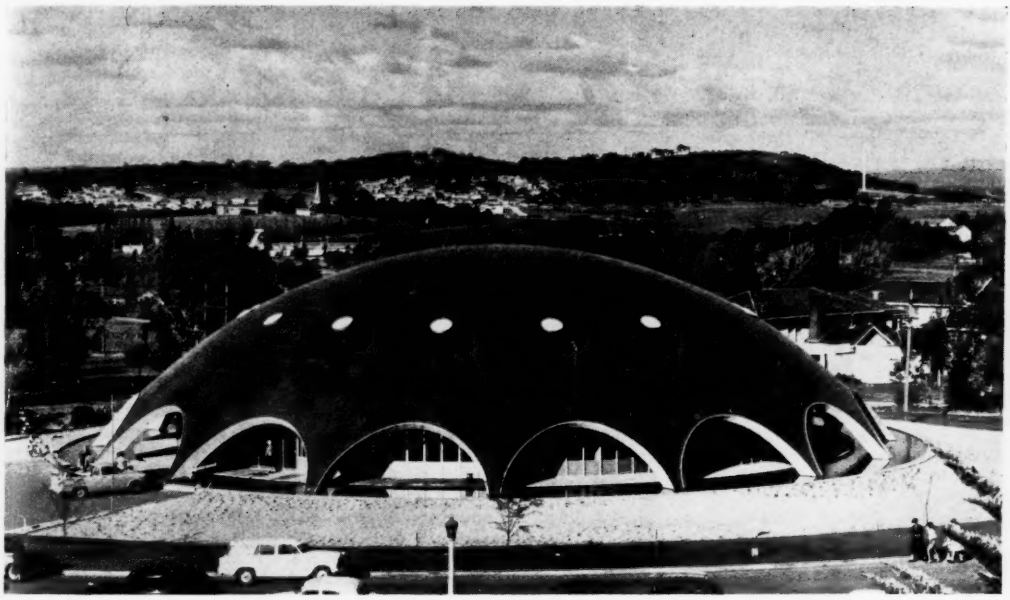

Fig. 1. New Building of the Australian Academy of Science, in Gordon Street, Canberra

by providing the finance for research projects. Benefactors would be secure in the knowledge that their contributions were being administered by the collective scientific wisdom of the Academy, rather than by the authority of any one scientist, however eminent.

The copper-sheathed dome of the new Academy building (Fig. 1), rising from the waters of a surrounding moat, is backed by the rolling bronze-green hills of Australia's national capital, Canberra. Beneath the dome is a central conference chamber, with luxurious seating for 190 and comfortable seating for a further 100, and a ring of offices, council room, and a superb reception room which overlooks an expanse which will within a few years be part of the central lake-system of Canberra. The conference chamber will be the venue of the annual meetings of the Academy itself, and will be extensively used for meetings of Australian scientific and professional societies, as well as for such international symposia as may be held in Australia.

The national responsibilities of the Academy receive material recognition from the Commonwealth Government in the form of an annual grant towards current expenses. The Academy, however, remains autonomous, and indeed the value of its services is derived very largely from its autonomy. It is too young a body to have achieved financial self-sufficiency through endowments; but the erection of the conference chamber and offices has been made possible entirely because of generous contributions to the Academy building fund by Australia's great industrial firms. To these firms, to the architects, and to the vision and energy of the members of its early Councils, the Australian Academy of Science, and Australia, owe a debt of gratitude; for they have created one of the most striking and important structures in Canberra, and they have provided the Academy with a home of its own which is modern, dignified, and of the highest quality.

MERLIN; AN INDUSTRIAL RESEARCH REACTOR

By Dr. T. E. ALLIBONE, F.R.S.

Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston Court, Berkshire

THE *Merlin* research reactor is situated at the Research Laboratory of Associated Electrical Industries, Ltd., at Aldermaston Court in Berkshire. It was made critical for the first time on July 16, 1959.

The decision to install a reactor for fundamental research at Aldermaston was taken in 1955 and the Associated Electrical Industries–John Thompson Nuclear Energy Co. undertook to supply it. The nuclear physics aspects of the reactor and the design of the control system have been the responsibility of the Associated Electrical Industries Research Laboratory; the mechanical engineering design, the erection and the commissioning of the equipment up to the stage of loading fuel into the reactor have been the responsibility of Associated Electrical Industries–John Thompson. Loading of fuel began on July 6 by the staff of the Laboratory, who are now engaged on the proving trials of the reactor. These trials, which involve thermal, mechanical, electrical and physical measurements, will extend into 1960, while the reactor power is gradually increased to a maximum of 5 MW.

The original design of the reactor was for a maximum thermal power of 1 MW. However, the shortage of test facilities in research reactors in the United Kingdom was impressed upon Associated Electrical Industries, Ltd., by the Atomic Energy Authority, and inquiries from overseas indicated that a 5 MW. reactor was a more likely export, so the design was altered to achieve a power of 5 MW. type which is characterized by a large maximum fast *Merlin* is of the light-water-cooled and moderated (> 1 MeV.) neutron flux per unit of power. The maximum unperturbed fast flux with 3·4 kgm. of uranium-235 in the core is 6×10^{13}/cm.^{2}/s.; the average fast flux in the nuclear power reactors being built for the Central Electricity Generating Board is about 10^{13}/cm.^{2}/s. Because it is the fast neutrons which contribute a large portion of any irradiation damage to materials in a reactor, it should be possible to carry out life tests on materials subject to radiation in power reactors. It is believed, therefore, that *Merlin* will be a very useful addition to the research and testing reactors in the United Kingdom.

A view of the reactor as seen from the experimental floor is shown in Fig. 1. The reactor has been described in detail elsewhere[1]; it is of the pool type, using fuel highly enriched in uranium-235 suspended in a tank of light water. The minimum cold, unpoisoned critical mass of the reactor has been shown in subcritical experiments to be about 2·6 kgm. of uranium-235[2], from which the mass of uranium-235 required to provide a reactivity of 0·055 is calculated to be about 3·4 kgm. With a beryllia reflector, 3 in. thick, added around the vertical sides of the core the corresponding masses of uranium-235 are estimated to be 2·18 kgm. and 2·87 kgm., respectively. The maximum reactivity of the core has been limited to 0·055 for safety reasons. The maximum unperturbed thermal neutron flux with 3·4 kgm. of uranium-235 in the core is 5×10^{13}/cm.^{2}/s.; the average thermal flux in the Central Electricity Generating Board power reactors is about 2×10^{13}/cm.^{2}/s.

The reactor is unusual in that the core can be moved vertically to four positions. The top position permits the addition or withdrawal of fuel or experimental apparatus from the core; the moving core structure can be seen in Fig. 1 as it appears from the top floor of the reactor building when the core is in its highest position. At two lower positions the core is in the plane of sets of experimental facilities, which can be seen in Fig. 2. The lowest position is for storage of the core and is so arranged that the possibility of loss of coolant from the tank in this region is negligible.

The area occupied by the reactor and its associated buildings is close to Aldermaston Lake. The large building contains the reactor and the main experimental area, the reactor control room, the fission-product detector and the ventilation plant for the building. Nearer the lake is the primary coolant pump house, the secondary coolant pump house, a

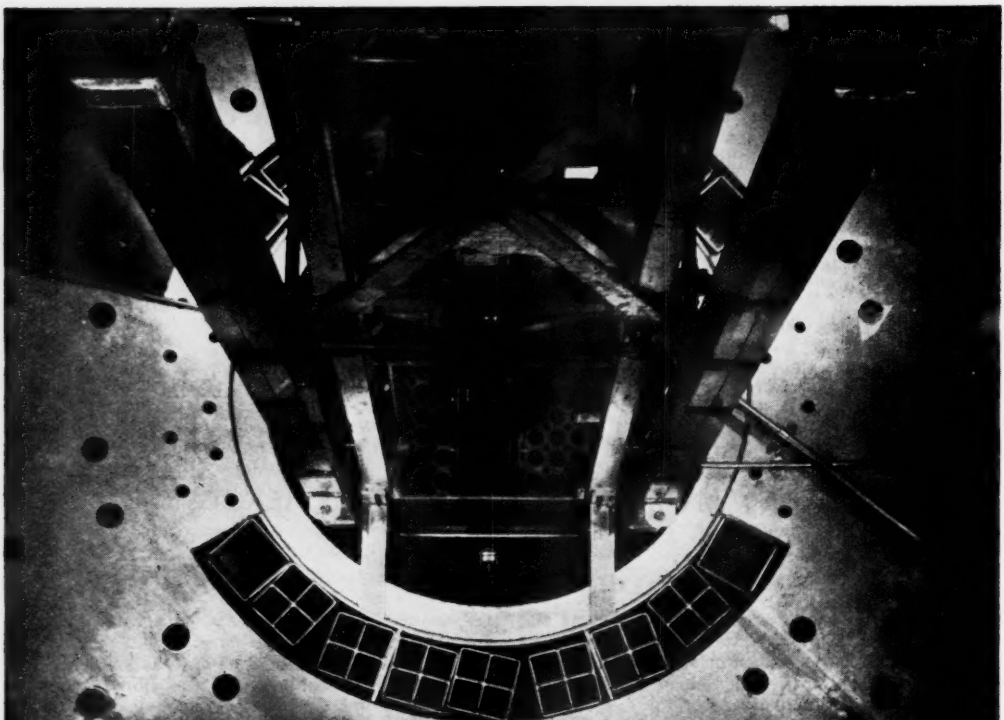

Fig. 1. A view into the reactor tank with the core lattice plate at its highest position. Four fuel elements can be seen in position on the lattice plate. The rectangular containers, in the foreground, are for temporary storage of active fuel elements

laboratory for sub-critical studies of the reactor core, an effluent plant for processing liquid effluent by filtration and ion-exchange before disposal and a personnel change room for use when entering and leaving the area in which contamination might occur. Four further small laboratories and offices are between the reactor and the lake. Twenty fixed radiation monitors are situated at positions throughout the buildings and in the effluent discharge system, and a further four monitors are situated approximately symmetrically around the reactor, at a distance of several hundred yards, to provide a warning of any undue release of airborne radioactivity.

The proposed research programme for *Merlin* covers both the fundamental and applied aspects of reactor research. Fundamental research being planned includes: the provision of nuclear data, the effects of radiation on materials, a study of Čerenkov radiation in reactors, and methods of measuring neutron spectra. The applied aspects of the research, which will certainly involve some fundamental work also, include: activation analysis, reactor control and safety studies, and the production of short-lived radioactive isotopes.

The Universities of Birmingham, London, Oxford, Reading and Southampton have been invited to consider how they might best use the reactor for the instruction of senior undergraduate and postgraduate students. Members of several university departments and of large polytechnics have spent several weeks with the reactor team, and during this summer a number of postgraduate students from the universities will be working in the laboratory on some research project associated with *Merlin*. University departments have been invited to arrange brief visits to the reactor for final-year students in physics, metallurgy and engineering, and longer visits for postgraduate students.

Dr. A. J. Salmon is the section leader in charge of the project, and the detailed work in the physics, electrical and mechanical engineering of the reactor has been the responsibility of Dr. K. Firth, Mr. B. Millar and Mr. I. Munro, respectively. The Reactor Section, together with the Thermonuclear and Nuclear Physics Section, constitute the Nuclear Sciences Group led by Mr. D. R. Chick, who is also responsible for the overall safety from nuclear hazards. Mr. J. N. Barnett, the Laboratory supervising engineer, has been responsible for the lay-out of this site, with Messrs. Atkins and Partners acting as consultants.

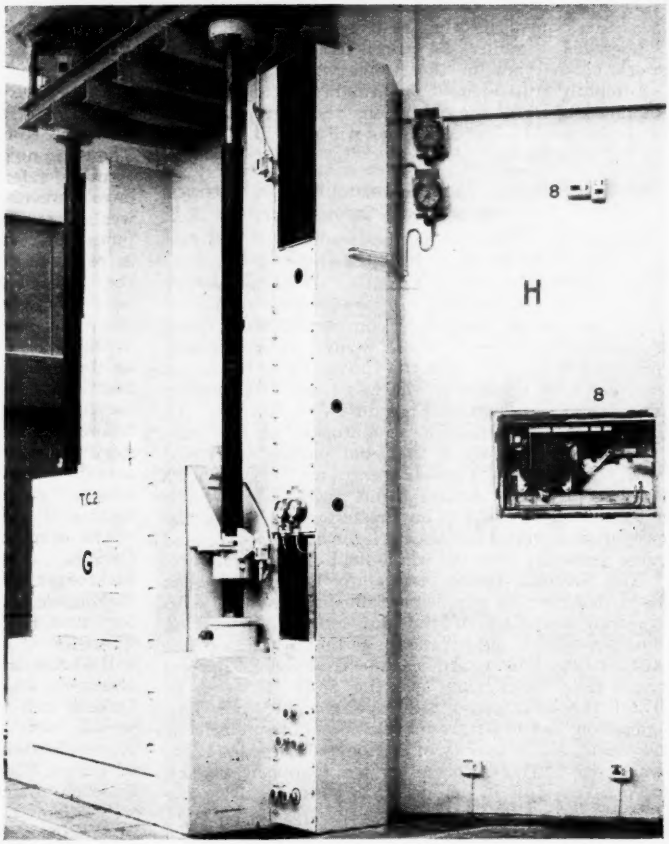

Fig. 2. The reactor and its experimental facilities as seen from the experimental floor

[1] Allibone, T. E., Chick, D. R., Firth, K., Millar, B., Munro, I., and Salmon, A. J., Geneva Conference Paper No. 313 (1958).
[2] Chick, D. R., Firth, K., Kerridge, M., and Salmon, A. J., *Nature*, **181**, 1171 (1958).

NEWS and VIEWS

Sir Owen Wansbrough-Jones, K.B.E., C.B.

At the end of September, Sir Owen Wansbrough-Jones is resigning from the position of chief scientist to the Minister of Supply. After taking his Ph.D. in the Department of Colloid Science at Cambridge, he spent some time with Hahn in Berlin. He returned to Cambridge both to his old department and to his college, Trinity Hall. There were excellent prospects of a brilliant academic career before him but, just as with his brother, he felt the call to the Army. He succeeded Sir Charles Ellis as scientific adviser to the Army Council. It has been said that the number of civilians who can understand the Army can be counted on the fingers of one hand. Wansbrough was certainly one of them. After some years of close contact with the Army Staff, he realized that he would serve them best by doing his utmost to ensure that the Army gained the weapons that they needed and he consequently moved over to the Ministry of Supply. During Wansbrough-Jones's

period of office there has been a notable growth of the scientific spirit in the Minister's establishments. Under his stimulus the research and development work carried out in the Ministry has proved exceptionally fruitful, and is probably better in spite of national economic conditions than anything like it in the world. His colleagues will miss him greatly in his retirement.

The U.S. National Radio Astronomy Observatory : Prof. Otto Struve, For.Mem.R.S.

Prof. Otto Struve has been appointed the first director of the National Radio Astronomy Observatory, Green Bank, West Virginia. The Observatory is being constructed and will be operated by Associated Universities, Inc., under contract to the National Science Foundation. Prof. Struve is at present professor of astronomy in the University of California and has been director of the Leuschner Observatory since 1950. He assumed his duties on July 1. An astronomer of international reputation, he has published approximately a thousand papers concerned with the problems of stellar spectra and other aspects of astrophysics. Although his principal scientific interest has been his important research on the properties of variable stars, his interests have extended more generally over the whole field of astronomy.

The National Radio Astronomy Observatory has been designed to supplement facilities available to research scientists of the universities by making available large and precise radio telescopes not hitherto available to American astronomers. Among these new instruments are the 85-ft. Howard E. Tatel precision radio telescope recently put into operation, the 140-ft. radio telescope now under construction, and a variety of auxiliary devices for radio astronomy. The Observatory is operated by a small permanent staff in co-operation with an increasing number of visiting scientists from various parts of the world.

1964 Olympic Games : Prof. Ryotaro Azuma

That the 1964 Olympic Games are to be held in Tokyo is largely due to the efforts of Ryotaro Azuma, formerly professor of pharmacology in the University of Tokyo, who was recently elected governor of Tokyo. Azuma, a distinguished member of the Japanese scientific community, has always encouraged the Olympic ideal of friendship and sportsmanship in international relations. He is a keen sportsman himself—he has rowed for the University of Tokyo; he also introduced the 'shell' to Japan from Britain, where he studied at University College, London, during 1922–24. Azuma is a member of the International Olympic Committee and in 1947 he was asked to head the Japan Athletic Federation. He played an important part in organizing the Asian Games which were held in Tokyo in 1958. Under his leadership sports for enjoyment, as opposed to sports as a form of regimentation, have had an immense success in Japan. Azuma sees a very close connexion between sport and Japan's post-war constitution renouncing militarism; but in his own words: "We must still educate the younger generation that it is not a disgrace to lose if you do your best".

Overseas Research Council

The Overseas Research Council promised at the Commonwealth Trade and Economic Conference at Montreal last September has now been established. In a statement in the House of Lords, Lord Hailsham said that the Council, of which Dr. R. S. Aitken will be chairman, will provide a central point to which Commonwealth Governments and research institutions can refer for advice and information, and it will advise generally on United Kingdom co-operation in scientific research overseas. There are no geographical restrictions in the Council's terms of reference, and matters concerning scientific development in Colonial territories, in Commonwealth countries and in countries outside the Commonwealth, can equally be referred to it. Moreover, in promoting such development Lord Hailsham said the Council could look to possible collaboration between Great Britain and other Commonwealth countries, countries outside the Commonwealth, such as the United States, and international agencies, such as those of the United Nations and the charitable foundations. Asked whether the members would be paid, Lord Hailsham said he would require notice before replying in detail but he believed certain officers might be paid. There would be a certain amount of travelling and the members of the Council had been selected largely for their knowledge of overseas territories and connexions with science in them.

The other members of the Council are: Sir Jock Campbell, Sir Charles Dodds, Sir Harold Himsworth, Sir Joseph Hutchinson, Dr. R. Lewthwaite, Prof. J. McMichael, Sir Harry Melville, Mr. E. D. W. Nye, Sir Arnold Plant, Sir William Slater, Dr. H. G. Thornton and Sir Solly Zuckerman. The Council will advise the Privy Council Committee on Overseas Research, which consists of the Lord President of the Council and the Secretaries of State for Commonwealth Relations, the Colonies and Foreign Affairs. Its terms of reference comprise advice on the formulation of United Kingdom policy in respect (*a*) of scientific research undertaken in or for overseas territories within or without the Commonwealth, (*b*) of methods of making the results of research available in these territories, and (*c*) of assistance to the scientific services of these territories; on the co-ordination of the activities of United Kingdom Government organizations in the development of science in the civil sphere in overseas territories; and on co-operation within the Commonwealth, with other countries and with international agencies in promoting such development.

National Institute for Research in Nuclear Science

Contracts for more than £430,000 have been placed by the National Institute for Research in Nuclear Science for the manufacture of the magnet coils required to energize the 7,000-ton electromagnet of the 7,000-MeV. proton synchrotron. This machine, which has been named *Nimrod*, is being built for the Institute by the United Kingdom Atomic Energy Authority at the Rutherford High Energy Laboratory, Harwell. Contracts have been awarded to British Copper Refiners, Ltd., of Prescot, Lancs., for the supply of more than 300 tons of refined copper (from which the coils are to be made), in the form of cast billets; to James Booth and Co., Ltd., of Birmingham for extrusion of the cast copper into hollow rectangular bars; and to Metropolitan-Vickers Electrical Co., Ltd., of Manchester, for the manufacture of the finished coils from the extruded bars. The Institute has also awarded a substantial contract to Marston Excelsior, Ltd., of Wolverhampton, for the development and supply of the reinforced plastic vacuum chamber in which the protons are

accelerated. This chamber will be one of the largest plastic structures ever made.

Extension to the Chester Beatty Research Institute

On July 16, Sir Chester Beatty laid the foundation stone of an extension to the Chester Beatty Research Institute. The cost of the extension (£200,000), which will double the existing accommodation, is being defrayed from a trust fund deriving from the charitable public, and administered for the benefit of the Institute by the Board of Governors of the Royal Marsden Hospital. A contribution of £40,000 has also been made by the Wellcome Trust, in respect of which the extension will include a Wellcome Laboratory of Pharmacology and Experimental Chemotherapy. The Research Institute of the then Cancer Hospital, established in 1909–10 and opened in 1911 by H.R.H. the Duke of Connaught, was directed successively by the late Dr. Alexander Paine, Dr. Archibald Leith and Sir Ernest Kennaway. In 1938, Sir Chester Beatty (who was then president of the Hospital) bought, equipped and presented the existing building, which thenceforth became the Chester Beatty Research Institute. The Institute is now part of the Institute of Cancer Research: Royal Cancer Hospital, which in turn is a school of the University of London, and an institute of the British Postgraduate Medical Federation. The Institute obtains its main support from the Medical Research Council and the British Empire Cancer Campaign, and donations and legacies are received from the public. Generous help has also been given by the U.S. Public Health Service and other American sources such as the Jane Coffin Childs Memorial Fund for Medical Research and the Anna Fuller Fund of New Haven, and the Rosenstiel Foundation of New York City. The new building, of which the architects are Messrs. Lanchester and Lodge, will be formally opened in 1960, when the Institute celebrates its jubilee year.

First Atomic Merchant Ship

The special illustrated supplement to the June 20 issue of *Atoms for Peace Digest* is devoted to a detailed description of the N.S. *Savannah*, the world's first atomic merchant ship, which was launched by Mrs. Eisenhower on July 21, at the New York Shipbuilding Company's Yard in Camden, N.J. The *Savannah*, a joint project of the U.S. Maritime Administration and the Atomic Energy Commission, has been built mainly to promote the peaceful uses of atomic energy and will not be commercially competitive. The vessel is named after the S.S. *Savannah*, the first steam ship to cross the Atlantic, which started her voyage from Savannah, Georgia, to Liverpool on May 22, 1819, and is a combination passenger–cargo vessel, 595 ft. long, with a beam of 78 ft. She can carry 9,500 tons of cargo and accommodate 60 passengers, and will be manned by a crew of about 100. Her speed is estimated at 20¼ knots. The *Savannah*'s reactor consists of a system of advanced design using pressurized water as a coolant and moderator, and fuel elements with about 4 per cent uranium-235 enrichment. The active core, which is 66 in. high and 62 in. mean diameter, contains the fissile material—7,050 kgm. of uranium oxide in 32 fuel rods, clad in stainless steel. There is a surrounding pressure vessel, primary shield, containing vessel and secondary shield, of 2,500 tons total gross weight. The reactor will supply 74 MW. of heat, providing sufficient power for the vessel to operate for about three years and to sail 300,000 nautical miles without refuelling. It is being built by Babcock and Wilcox at Lynchburg in Virginia at a cost of about ten million dollars. The total cost of the ship will be about 40 million dollars.

Labour Statistics

The Interdepartmental Committee on Social and Economic Research has recently issued a revised version of its guide to the statistics collected by the Ministry of Labour and National Service (Guides to Official Sources: No. 1, Labour Statistics. H.M. Stationery Office, London, 1959. 5*s*.). The opportunity has been taken to bring the material in the original edition up to date and to include a historical section, showing the development of labour statistics in Britain since the end of the nineteenth century. The topics covered include statistics of employment, unemployment, placings and vacancies, miscellaneous man-power statistics, wage rates, earnings and actual hours worked, strikes and industrial disputes, industrial accidents, the cost of living, retail prices and family budgets. Each of the sections is followed by a comprehensive bibliography of official sources.

World Distribution of Atmospheric Water Vapour Pressure

The Meteorological Office is much more than a forecasting institution. It is the public repository of knowledge regarding the weather, and among its many functions is the provision of data on a world-wide scale for a variety of users. "World Distribution of Atmospheric Water Vapour Pressure", by G. A. Tunnell (Geophysical Memoirs, No. 100. Pp. i+61. M.O. 584*h*. London: H.M. Stationery Office, 1958. 10*s*. net) is an atlas of the distribution over the whole world of the daily mean of atmospheric water vapour pressure for the months January, April, July and October, based on records from 3,500 stations. There follows a brief survey of the world distribution of diurnal variation of vapour pressure in different climates. Information concerning atmospheric humidity in all parts of the world is thus available in compact form for industrialists and others who may require it. Mapping is done by means of isopleths. In common with all such maps, the distributions so revealed have many interesting features not always readily explained. For example, taking account of the characteristics of Russia, is the breadth of the patch of higher vapour pressure shown both in January and July near Kazan real? The midsummer variations in the mean vapour pressure over South Australia are also noteworthy. An agreeable publication, clearly printed, informative, and stimulating in respect of the distribution shown; the policy of the Meteorological Office in producing such memoirs will be widely welcomed.

The Customs and Religion of the Ch'iang

The Ch'iang inhabit a mountainous region in Szechwan in western China and grow maize as the main crop. They speak a Burmese–Tibetan language and are said to have formerly lived in north-eastern China. For some time past, however, they have been losing their own culture and adopting that of the Chinese, with whom they were earlier in conflict. We have such meagre information on the non-Chinese population of China that almost any report is of value. Mr. D. C. Graham (Smithsonian Miscellaneous Collections, 135, No. 1: The Customs and Religion of the Ch'iang. Pp. vii+114+16 plates.

Washington, D.C.: Smithsonian Institution, 1958) has collected a considerable amount of material in the course of various expeditions to the area between 1925 and 1948. This he presents in a straightforward manner, and although he has little acquaintance with anthropological literature he does at least lay two ghosts assiduously fostered by another missionary, the Rev. Torrance, who had claimed not only that the Ch'iang were monotheists but that they were also descended from one of the far-ranging tribes of ancient Israel. On the positive side, scholars will be grateful for the information on religious beliefs and practices, particularly the eye-witness account of the ceremonies in the sacred grove. As in many other parts of the world, these rituals provide some inclusive focus for the village as a whole, while the ancestral cult serves a similar function in respect of the constituent descent groups.

Australian Mammal Society

At the Australian and New Zealand Association for the Advancement of Science meeting in Adelaide, held during August 1958, it was decided to form an Australian Mammal Society, for the time being restricted to professional workers actively interested in indigenous Australian species. Members of the Society are made aware of the work and material requirements of fellow members and the interchange of material between members is encouraged. The inaugural meeting of the Society was held in the Department of Zoology, University of Western Australia. The following are the foundation members of the Society: J. H. Calaby, F. N. Ratcliffe (A. C. T.); Dr. A. Bolliger, Dr. R. G. Chittleborough, Prof. K. W. Cleland, W. H. Dawbin, Dr. A. G. Lyne, B. J. G. Marlow, E. Le G. Troughton (New South Wales); A. E. Newsome (Northern Territory); Dr. J. L. Harrison (Queensland); Phyllis Pilton, G. B. Sharman (South Australia); C. W. Brazenor, J. McNally, J. A. Thompson (Victoria); Jennifer M. Barker, S. Barker, C. H. Tyndale-Biscoe, E. H. M. Ealey, Dr. W. D. L. Ride, Dr. J. W. Shield, G. M. Storr, Prof. H. Waring (Western Australia). The secretary-treasurer for 1958–59 is Mr. S. Barker, Department of Zoology, University of Western Australia.

Linnean Society of London: Officers

At the anniversary meeting of the Linnean Society of London the following were elected officers for the session 1959–60: *President*, Prof. C. F. A. Pantin; *Treasurer*, the Earl of Cranbrook; *Secretaries*, Dr. H. R. Hewer (zoology), Dr. C. R. Metcalfe (botany), Dr. John Smart (editorial). Prof. L. J. Audus, the Earl of Cranbrook, Mr. A. W. Exell, and Dr. H. G. Vevers were appointed vice-presidents. Mr. E. J. H. Corner, Dr. G. Owen Evans, Mr. C. C. Hentschel, Dr. A. Melderis and Mr. Wm. T. Stearn were elected new members of council. Linnean Gold Medals were presented to Prof. H. Munro Fox and Prof. Carl Skottsberg. Prof. Jean G. Baer was elected a foreign member and Mr. Warren R. Dawson an Associate *honoris causa*.

Ramsay Memorial Fellowships

The Ramsay Memorial Fellowships Trustees have made the following awards of new fellowships in chemistry for 1959–60: a General Fellowship at the University of Aberdeen to Mr. P. J. T. Tait; a Canadian Fellowship to Mr. W. G. Paterson at the University of Oxford; a Japanese Fellowship to Mr. Toshinobu Anno at the University of Oxford; a Netherlands Fellowship to Dr. H. C. Volger at the University of London (University College); Spanish Fellowships to Dr. Felisa Nuñez Cubero at the University of Nottingham; Mr. J. B. Callija at the University of Bristol; Swiss Fellowships to Dr. Otto Stamm at the University of London (Imperial College of Science and Technology); Dr. Fritz Kneubühl at the University of Southampton. The Trustees have renewed the General Fellowship to Mr. G. S. Laurence for work at the Atomic Energy Research Establishment at Harwell.

City of Paris Medal Awards

At the recent International Conference on Information Processing held at Unesco House, medals of the City of Paris were awarded as follows: The Vermeil Medal to Prof. Howard H. Aiken (United States); Silver Medals to I. I. Basilewsky for Prof. Dimitri Panov (U.S.S.R.); Isaac L. Auerbach (United States); Maurice V. Wilkes (United Kingdom); Adriaan van Wijngaarden (Netherlands); Hideo Yamashita (Japan); Alwin Walther (German Federal Republic); Aldo Ghizzetti (Italy); Stig Comet (Sweden).

Announcements

Sir Hugh Linstead has been appointed a member of the Medical Research Council in the place of the late Mr. Richard Foot, M.P.

Mr. Henry Edmunds, county advisory officer for Breconshire, has been appointed assistant agricultural and food attaché in Washington. He replaces Mr. O. G. Williams.

Dr. J. H. Piddington, of the Commonwealth Scientific and Industrial Research Organization (Australia) Division of Radiophysics, has received the T. K. Sidey (Summertime) Award, made each year by the Royal Society of New Zealand. The Award was given for his theoretical explanation of heating in the atmosphere of the Sun. He also received the David Syme Research Prize of the University of Melbourne recently for this work.

The following officers of the Institution of Electrical Engineers have been elected: *President*, Sir Willis Jackson; *Vice-Presidents*, G. S. C. Lucas, O. W. Humphreys; *Honorary Treasurer*, E. Leete.

The Quality Control Group of the Textile Institute will officially come into being on November 10, when a conference on this subject will be held in Harrogate. Further information can be obtained from Mr. L. H. C. Tippett, British Cotton Industry Research Association, Didsbury, Manchester. The inaugural meeting and conference of the Physics Group of the Institute will be held in Buxton on October 8 and 9. Further information can be obtained from Dr. H. O. Pauls, British Nylon Spinners, Ltd., Pontypool.

Butterworths Scientific Publications, Ltd., 4–5 Bell Yard, Temple Bar, London, W.C.2, announce that a new quarterly journal, *Polymer: a Journal to Promote the Science of Large Molecules*, is to appear in October. It has been founded to provide an international medium for the publication of original papers on the chemistry, physics and application of polymer research. The Advisory Editorial Board consists of: Dr. C. H. Bamford, Courtaulds, Ltd., Research Laboratory, Maidenhead; Prof. C. E. H. Bawn, University of Liverpool; Prof. Geoffrey Gee, University of Manchester; and Dr. Rowland Hill, research director, I.C.I. Fibres Division, Harrogate.

THE WATER POLLUTION RESEARCH LABORATORY

THE Water Pollution Research Laboratory of the Department of Scientific and Industrial Research held open days on May 6 and 7. This organization was formed in 1927, but the Laboratory at Stevenage was not occupied until October 1954. The total staff, which includes chemists, chemical engineers, physicists and biologists, is at present about 120. The Station carries out small-scale and pilot-scale work and also has facilities for work with large plant built in the open, particularly on the treatment of sewage, which can be pumped from a domestic sewer crossing the site. It was stated that an additional wing, containing further pilot-scale laboratories, is being designed and that it will probably be built in 1960.

The field of work of the Station is in the improvement and development of methods of treating sewage and industrial effluents, and in the study of the effects of pollution on surface waters, including rivers and estuaries. Of the work on sewage, part is of an empirical kind and part more fundamental. In the first category, for example, the Laboratory is comparing the efficiency of different types and size of medium in percolating filters, of which there is a large experimental installation in the grounds. The more fundamental work on sewage includes a detailed study, mostly with pilot plant, of the mechanism and efficiency of aeration in the activated-sludge process, of the factors affecting the drying of sewage sludges, and of the effect of household detergents on sewage treatment. Apart from the obvious effects of these materials—that is, the occurrence of foam, often some feet deep, at sewage works—they have caused a marked deterioration in the biological processes of treatment at some works, particularly at those which use the activated-sludge process, in which sewage is aerated either mechanically or by diffused air in contact with an active bacterial floc. Work at Stevenage has shown that the immediate effect of detergents is to reduce the rate of transfer of oxygen from bubbles of air to the liquid, and that in those plants where initially the rate of aeration was sufficient only to maintain a comparatively small concentration of oxygen in solution, the further inhibition of oxygen transfer has been responsible for the deterioration observed. It was announced recently that manufacturers of detergents were trying to develop surface-active materials which would be more easily decomposed by bacterial action than those at present in use, and in one experimental plant at the Laboratory some of the more promising compounds were being tested by treating them, in admixture with domestic sewage, in small activated-sludge plants. In these tests the conditions of operation are controlled; for example, the liquid is aerated with mixtures of air and nitrogen to maintain a desired constant concentration of oxygen in solution. Some of the materials submitted for test are much more readily decomposed during sewage treatment than are those at present on the market.

A substantial effort is directed to the improvement of methods of treating industrial waste waters, and in this work the Laboratory is closely associated with the Federation of British Industries. One investigation now nearing completion has dealt with the anaerobic digestion of certain industrial liquors—for example, those from slaughter-houses—containing high concentrations of organic matter. For suitable liquids this process may well be economic—for example, with slaughter-house waste more than 90 per cent of organic carbon is converted to methane and carbon dioxide during a period of treatment of 24 hr. —and the process is likely to go into full-scale use in Britain in the near future. A plant was also shown in which tannery wastes, which often contain sodium sulphide used for removing hair from hides, is treated with flue gas to neutralize it, the hydrogen sulphide in the flue gas being oxidized to sulphuric acid by biological action in a percolating filter. Apart from these long-term projects the Laboratory acts as an advisory service to industry and frequently undertakes short investigations for particular firms on a repayment basis.

One important aspect of the work of the Laboratory is the study of the effects of polluting substances in surface waters. For some years the chief object of this study has been the Thames Estuary, the central reaches of which in dry weather are anaerobic, and where in consequence sulphate is reduced to sulphide by bacterial action. This survey, the final report on which has not yet been published but is in preparation, has involved much experimental work—for example, determinations of rates of oxidation of organic materials at different temperatures, and the study of the conditions in which ammonia is oxidized or nitrate is reduced by bacterial action—the results of which are applicable to the far simpler system of a fresh-water stream. In the Thames Estuary the most important effect of pollution of all kinds is to reduce the concentration of oxygen in solution in the water, since it is only when this has fallen to zero (and when any nitrate present has been reduced to nitrogen) that evolution of hydrogen sulphide occurs. In fresh-water streams many other effects of polluting substances may be important, particularly if the stream is expected to support a fishery or if the water is used for a public supply, but the lowering of the concentration of dissolved oxygen which results from the discharge of any oxidizable material is still one of the most objectionable results of pollution, and the level of oxygen is often taken as diagnostic of the general quality of the water.

In rivers which contain fish, oxygen tension is particularly important, not only because a certain minimum level is necessary to support fish life, but also because a reduction in tension increases the toxicity of any poisons which may be present. The Laboratory is studying the various factors which govern the oxygen balance of streams, in the hope of being able to reduce the margin of error with which the oxygen profile below the point of discharge of a given effluent to a given river can be predicted, and has already made some progress in this direction. The work has been greatly facilitated by the development of a robust recorder of the dropping-mercury type which can be used to give a continuous record of the level of dissolved oxygen in a river. The programme involves a knowledge of the rate of oxidation of

polluting substances, of the rate at which the water of a stream will absorb oxygen from the air, and of the effects of aquatic plants and animals on the oxygen balance.

In the field, the only satisfactory method at present available for determining the rate of transfer of oxygen from the air is to reduce the oxygen tension in the water (by adding sulphite and a catalyst), following then the rise in level of oxygen below this point. This method has been used successfully for small streams, but presents obvious difficulties in a large river. Many of the factors involved, however—for example, turbulence, and the presence of substances such as detergents in solution which reduce the rate of oxygen transfer—are being investigated by running water through sloping troughs, 100 ft. long, in the grounds of the Laboratory. One question which is often important in Britain—namely, the change in oxygen-level in water when it flows over weirs—has been substantially settled by work in the field and in pilot-scale plant; given the height from which the water falls, and the temperature, the extent to which the oxygen deficit is reduced can be predicted within narrow limits.

In rivers, oxidation and reduction of compounds of nitrogen often play an important part. Oxidation of ammonia and reduction of nitrate, and particularly the effect of concentration of dissolved oxygen on these processes, are being studied in an artificial river in which water passes through a series of tanks fitted with stirrers. In streams containing large numbers of algae or much rooted vegetation, the effects of the bacterial oxidation of polluting matter on oxygen tension may be greatly outweighed by photosynthetic production of oxygen and its consumption by plant respiration. These effects are being studied in a stream near the Laboratory, where continuous recorders are installed. In June and September 1958 there was a net release of 3·8 gm. oxygen/m.^{2}/day. Estimates are being made of the productivity of different reaches in this stream using cropping techniques assisted by aerial photographs taken by a camera suspended from a meteorological balloon. Consumption of oxygen by respiration of invertebrates is also significant, and this is being determined in respirometers in which the change in oxygen tension is again recorded continuously.

The Laboratory has a small but well-equipped Microbiological Section in which three main lines of work are in progress. The first is a detailed study of the changes which occur when aqueous solutions of organic compounds (which may be radioactively labelled) are passed over an active microbial film of the type which occurs in percolating filters and on which the purification of sewage by this process depends. The film is built up on the inside of a 'Perspex' cylinder, the long axis of which is inclined and about which it is rotated; the atmosphere in contact with the film is circulated and there are arrangements for withdrawing samples from it and for adding oxygen to replace that used in oxidation. Most of the organic substances present in such materials as sewage are very rapidly oxidized; one object of the work is to identify those which are not.

It is very important, in treating polluting liquids by biological processes, to be able, in the last stage of the process, to remove by sedimentation organic sludge from the liquid—the latter representing, of course, the final effluent from the plant. A large part of the organic matter to be removed consists of bacteria and the quality of the final effluent depends very largely on whether they will or will not agglutinate in the final sedimentation tank. In spite of a good deal of work on the subject, not much is known of the factors which affect flocculation in a treatment plant; these are therefore being studied by the section, using cultures isolated from sewage and sewage effluents.

The third line of work which is being pursued in collaboration with the National Coal Board is on the bacterial treatment of waste waters from coke ovens, in which the chief constituents to be removed are phenols, thiocyanate and ammonia. Rates of assimilation and oxidation of these substances are being studied in continuous-culture apparatus after preliminary trials by the usual Warburg technique.

The Microbiological Section has recently been strengthened by the transfer to it of some of the staff formerly working at the National Chemical Laboratory.

WATER SUPPLY AND DEMAND IN GREAT BRITAIN

THE problem of water supply and demand, the need for improved hydrological knowledge and the necessity for a continuing study of the changing situation in Britain, have received editorial notice in earlier issues of *Nature* (**172**, 823; 1953, and **176**, 1133; 1955). The decision to suspend the Inland Water Survey and disband the Central Advisory Water Committee during the economy measures of 1952 was, from a purely scientific point of view, strongly criticized. Happily this decision was reversed in 1955 when the Central Advisory Water Committee was reconstituted; and in the same year the Inland Water Survey also recommenced its labours and has since published a great deal of information covering the post-war years.

One of the first actions taken by the Central Advisory Water Committee in 1955 was to appoint two subcommittees to investigate information on water resources and the growing demand for water. Both these subcommittees have recently reported to the Central Committee and the information collected so far has now been published*.

Of the two documents, that of the Subcommittee on Information on Water Resources is perhaps the least controversial and may be considered first. This Subcommittee was appointed with the following terms of reference: (i) to review the current activities which contribute to our knowledge of the nation's water resources; (ii) to define the additional work needed to make a balanced survey of the quantity and quality of surface and underground water available for domestic, industrial and agricultural use; (iii) to advise on ways of collecting and interpreting

* Central Advisory Water Committee. Subcommittee on The Growing Demand for Water—First Report. Pp. iv+28. 1*s.* 3*d.* net. Report of the Subcommittee on Information on Water Resources. Pp. ii+20. 1*s.* 3*d.* net. (London: H.M. Stationery Office, 1959.)

the necessary information, correlating it with information from other sources and publishing it.

The review of current activities deals with the work of the Meteorological Office (Air Ministry), the Surface Water Survey Centre (Ministry of Housing and Local Government) and the Geological Survey in providing information on rainfall, evaporation, surface water and ground water. It is recommended that the Geological Survey should resume publication of information on ground water; and that all data on rainfall, surface water and ground water should be presented on a common basis of river basin areas. The planned future contents of "British Rainfall" and the "Surface Water Year Book" are endorsed, and the proposed arrangements for the collection and interpretation of hydrological information are considered adequate to meet the known need, although certain extensions of existing activities are recommended. The more frequent inspection of rainfall stations, the more accurate recording of snowfall, additional recording of ground water, the publication of more data on the quality of certain water supplies and the more rapid completion of the network of river gauging stations are all considered desirable.

Although the arrangements for the collection and interpretation of information are considered "broadly [to] meet the known need", the report recognizes the necessity for additional investigation into hydrological relationships and for further inquiry into the use of hydrological information. It is therefore also recommended that work at present being done on hydrological research should be reviewed to determine how such work should be co-ordinated and what extensions or modifications may be desirable. The lack of any central hydrological information and research organization comparable to the Geological Survey or Meteorological Office has already been noted elsewhere*. The publication of this report on information on water resources really arises from the lack of such a body, since data on the hydrological cycle in Great Britain are scattered among such a variety of authorities: each of these authorities is only interested in one aspect of the complete cycle. The recommendation that all hydrological results should be presented on a common basis of hydrometric areas is, however, a significant move towards a closer integration of the available data.

The report of the Subcommittee on the Growing Demand for Water is a longer document, although despite three years deliberation and investigation it has appeared as a first and not as a final report, for the subcommittee found its terms of reference more exacting than anticipated. These were "To consider the extent to which the demand for water for domestic, industrial, agricultural and other purposes is increasing and is likely to increase, to consider the problems involved in meeting these demands, including, in broad terms, the cost; to consider whether there are any substantial economies in the use or cost of water which could be made without reduction in standards of hygiene or in industrial or agricultural efficiency; and to make recommendations".

The main questions which remain unanswered concern the demand for water for agricultural irrigation and economies in the use of water in industry. The chief difficulty experienced in the investigation was related to the dual character of water supply in Great Britain which is provided by both public water undertakers and obtained privately: and the threefold nature of the demand, which is domestic, industrial and agricultural. Accurate statistical information on consumption is readily available only from the public water undertakers, but even here the amounts in the various categories of use are not fully known. The subcommittee instituted its own official inquiry among all public water undertakers, the nationalized industries (electricity, coal, gas and transport), and six major industries (brewing, chemicals, iron and steel, leather, paper and textiles) where supplies are largely obtained privately. A large and valuable collection of new statistical data has therefore been accumulated; and this, together with the unpublished water surveys carried out between 1945 and 1958 by engineers of the Ministry of Housing and Local Government, form the basis of the recommendations accompanying the report.

In the industrial and domestic categories there is clear evidence of a steady nation-wide increase in water consumption of between 2 and 3 per cent per annum during the past quarter of a century. This is expected to continue into the future to produce by 1965 something of the order of a 25 per cent increase over the known 1955 consumption figures. As new works under construction, or proposed, are scheduled to yield an additional 800 million gallons of water a day by 1965, and this is approximately 40 per cent of the quantity distributed by water undertakers in 1955, the subcommittee concludes that in England and Wales as a whole the rising consumption need not give rise to immediate anxiety. This general statement is, however, immediately qualified with the proviso that "this is not to say that temporary or local shortages will not recur from time to time, quite apart from more general shortages in very dry years (when maximum domestic demand and minimum supply tend to coincide), or that industries seeking new sites will find abundant supplies in any place they care to choose". The estimates also assume that in any particular area the trend of consumption will follow approximately its present course, so that any significant deviation not foreseen at present could upset the balance.

Beyond 1965 the Subcommittee was "unable to obtain any reliable data" and decided not to attempt numerical estimates. The subcommittee is therefore not prepared to commit itself other than to express the opinion that there need be no shortage of water in any part of England and Wales provided that development schemes are prepared well in advance of demand, that the necessary statutory powers and other authorizations are granted, that capital investment is permitted on the requisite scale and the location of industries which require large quantities of water is regulated with the water supply situation in mind.

While acknowledging the great amount of work which has clearly gone into the inquiry, and the valuable new information which the report presents, it must be admitted that there are a number of debatable points. In the first instance the Subcommittee has based its arguments upon figures of past consumption which are not necessarily indicative of past demand, and could certainly be misleading so far as future demand is concerned. This is most evident in the agricultural usage of water. Quite apart from the fact that the consumption rises rapidly as soon as piped water becomes available to a farm, there is the whole unresolved and rapidly growing problem of agricultural irrigation. The work done at Rothamsted Experimental Station shows, for agriculture, a deficiency of rain in more than five years out

* Balchin, W. G. V., *Water and Water Eng.*, **61**, No. 734 (1957).

of ten south of a line drawn from the Humber to the Severn, and a deficiency in nine years out of ten in Essex, Suffolk and Kent. The magnitude of the deficiency varies from place to place and from year to year with theoretical values ranging from 1 in. to 12 in. of rain. The irrigation that would be needed to meet this deficiency would depend on soil moisture retention conditions and plant rooting characteristics, and might amount to a rainfall equivalent in some places of up to 6 in. All the water would be used in transpiration or evaporation, or absorbed by percolation, and would not be capable of re-use. Calculations indicate that a possible demand of some 8,000 million gallons a day might exist in very dry years south of the Humber–Severn line. This amount is more than four times that supplied in 1955 by all the public water undertakers in England and Wales, and it indicates the potential demand which exists and which the subcommittee has ignored in its first report. It is proposed, however, to give further attention to this problem, but the approach appears to be negative as the possibility is mentioned of some form of control over the abstraction of surface water analogous to the existing protection of underground water. If the national policy is to secure the maximum food output from the agricultural industry, farmers in south-east England should be actively encouraged rather than discouraged to irrigate, in which case a more positive approach to the water supply problem and a completely different attitude of mind are then needed.

The reluctance of the Subcommittee to look further ahead than 1965 is also unfortunate, although the difficulties can be fully appreciated. The Ministry of Health Committee on Causes of Increase in Consumption of Water (1949) was prepared to look ahead for a period of some 22 years up to 1970. Past experience clearly shows that water-supply schemes take many years to come into operation and that reliability in supply largely depends on one generation planning for the next. The blue prints to meet the requirements of the late 1970's should be in process of formulation in the early 1960's if the real needs of agriculture and industry are to be satisfied.

Possible economies in the use of water in industry have also been deferred for future consideration, although the report does direct attention to waste prevention and leak detection ; the recommendation is made that all water undertakers should operate an adequate waste prevention service.

There is clearly much food for thought in both of these reports. The rising standard of living of an increasing population in Great Britain has, in the present century, brought water to the forefront as a vital and essential commodity in the life of the nation. Although the natural resources of the country in terms of rainfall are theoretically adequate, Nature has a habit of distributing the precipitation unevenly in both time and place. This situation can only be remedied by care in use and by the conservation of supplies in periods and areas of plenty. Lowland Britain, where consumption is greatest, is also the area where the population is densest, the rainfall least and where local water resources are nearing full utilization. Highland Britain, on the other hand, has a low population, the highest rainfall and a relative over-abundance of water of which only a small proportion has yet been developed. To what extent would the gains from scientific irrigation in agriculture and a guaranteed domestic and industrial supply in lowland Britain outweigh the cost of storage and movement of water from highland Britain ? And how far might the conversion of saline water in Great Britain assist in the solution of the water-supply problem ? It seems that these are the major questions on water supply that must be answered if the problem is to be approached with vision and concern for the needs of the next generation.

W. G. V. Balchin

TEN YEARS OF ERGONOMICS

Ergonomics is mainly about 'human factors' in the design and operation of machines, and about the physical environments in which men use their machines. Moreover, it is multidisciplinary. Nobody who attended the tenth anniversary meeting of the Ergonomics Research Society, held in Oxford during April 6–9, could have much doubt on either of these points.

The Postmaster-General, Mr. Ernest Marples, apparently less damaged than he should have been by a 400-mile cycling trip in France on what seems to have been a highly unergonomic saddle, opened the conference. He had hard things to say about the word 'ergonomics'. Unlike his chairman, the Master of Balliol, who thought it was splendid because it told us exactly what it meant, Mr. Marples thought it was frightful because it did not. However, for ergonomics itself he had nothing but praise. The General Post Office had used it for nine years ; and it was his intention to build it into the General Post Office structure so firmly that it could be got out again only by 'positive action'. He pledged his support for everyone, everywhere, including housewives in their kitchens, who moved ergonomically with the times.

Following up a point Mr. Marples made about the frequency with which "backroom boys" are either not understood or misunderstood, Sir Frederic Bartlett, formerly—for twenty-one years—professor of experimental psychology in the University of Cambridge, inquired how common difficulties of communication might be overcome, so that proved advances (for example, in the design of altimeters) might be adopted with reasonable rapidity. Mr. Marples advised him to get into touch with the top people concerned, or with the Parliamentary and Scientific Committee, or with Mr. Marples himself. Sir Frederic looked rather less happy about this than did Mr. Marples.

There was more to come from the General Post Office. A paper by Dr. R. Conrad, of the Medical Research Council Applied Psychology Unit at Cambridge, dealt with mass communication systems ; and a couple by Dr. W. F. Floyd, of the Middlesex Hospital Medical School, and Miss June I. Jones, of the General Post Office, covered some problems of lighting, posture, thermal conditions and energy cost of work in telephone exchanges and Post Office factories. These gave a clear indication of what ergonomics amounted to in practice. Dr. Conrad told us that to obtain a weather report he had to

dial 96618312274. As this kind of thing was spreading, it had been decided that some General Post Office-based studies of immediate memory might pay off. One proved useful in comparing conventional dials with push-button arrangements; and another helped in working out the kinds of codes that might be suitable for trunk numbers or postal addresses. Dr. Conrad's concern with efficiency was matched by the interest Dr. Floyd and Miss Jones displayed in comfort; but Dr. Conrad led the other two in his theorizing.

These three early speakers did, in fact, throw up, without explicit formulation of them, problems which were to rear their heads frequently during the conference. What had Dr. Conrad in common with Dr. Floyd and Miss Jones apart from the General Post Office roof over his head? All he said—and, indeed, all his director, Mr. D. E. Broadbent, said in a later paper—could easily have been labelled 'applied experimental psychology'; and all that Dr. Floyd and Miss Jones said is usually called 'applied physiology'. Where does ergonomics come in? Does it seek to be regarded as a new science? If so, on what is its claim to independent scientific status founded? Has it any distinctive concepts or methods? Is it, perhaps, mainly a convenient gathering-place for people belonging to certain technological wings of certain human sciences, and their agents and users in industry?

As if these puzzles were not enough for us, more were produced by delegates who came from the work-study sector of industry. One, Mr. A. Graham, of Imperial Chemical Industries, created a small squall after some plain speaking by Mr. H. Murrell, the founder of the Society. Mr. Graham asked scornfully why industry should be expected to prefer the 'toothpick' of ergonomics to the 'pneumatic drill' of work-study; and having delivered himself of this broadside, he switched on his own pneumatic drill and demanded that work-study practitioners should be offered both help and respect. He gave the impression that what was really worrying him was the intrusion of still more outside 'experts'. At this point Mr. A. T. Welford, the editor of *Ergonomics*, deftly applied the oil-can. However, it seems that later in the day, at the Society's annual general meeting, Dr. E. A. Müller, of Dortmund, set the cat among the pigeons again by suggesting that meetings between research workers and people from industry were a doubtful blessing and should be only occasional.

It may appear, from all this, that the conference was a bit of a mix-up. So indeed it was. But it was probably a healthy one. The physiologists and psychologists, though going their separate and unintegrated ways, somehow did battle together with the delegates from industry. True, each side paid tribute to the other and to some extent shared a common cause; but the sparks flew. Perhaps even more would have flown if the meeting had been held in less academic surroundings. The industrial contingent were inclined to be a little shy.

The nature and quality of the papers were as mixed as the audience. Though the title given to the conference as a whole was "Symposium on Ergonomics, its Place in Industry (Past Progress and Future Trends)", only a few of the contributions played up to it. These came mostly at the beginning, from Mr. Welford and from Dr. O. G. Edholm, of the Medical Research Council Division of Human Physiology; and at the end, from Mr. Broadbent, from Dr. E. H. Christensen, of Stockholm, and from Mr. L. V. Green, of Dunlops. The rest were chiefly individual papers. Among them were a description of work done on design problems in E.M.I. Electronics, given by Mr. B. Shackel; and an account of activities in the Clothing and Stores Experimental Establishment of the Ministry of Supply, given by Dr. E. T. Renbourn and Mr. H. C. Stockbridge. Mr. C. E. Brooks, of Personnel Administration, Ltd., had some sensible things to say about improving the quality and output of inspectors by systematic re-training, but the information he produced in support of his findings did not carry conviction to everyone; nor did it seem to have much to do with ergonomics.

Despite this bittiness, a good deal of stimulation was provided. Mr. Murrell's own contribution, mentioned earlier, was not what he meant it to be, because a midnight argument had made him decide to scrap the original. In the event it turned out to be a usefully provocative statement about what 'ergonomists' could do for industry that methods engineers could not. They could bring to their task knowledge of the capacities and limitations of human beings not to be found in the publications of Shaw, Mundel or Barnes. More than that, they could bring to it skill in the conduct of experiments with 'chaps'. A methods engineer plus a psychologist or half a physiologist would produce a different outlook on industrial problems. This was the straight-from-the-shoulder stuff that caused offence to Mr. Graham. To some others it caused perplexity, for it left unclear the distinguishing characteristics of the ergonomist, the psychologist, and the physiologist. A few among the faithful were dismayed, because although they talk about ergonomics, they do not like the label 'ergonomist'.

In a comment on a paper by his E.M.I. Electronics colleague, Mr. J. R. Arrowsmith, Mr. Shackel had a good point to make about the function of machines in relieving the anxieties of skilled men who build up great tension as the possibility of spoiling several days work mounts. So had Mr. Broadbent, in the same discussion, when he remarked that in our hopes for the elimination of human error, through the taping of instructions, we must not neglect the risk that the typist typing the tape may err. Earlier, Mr. W. D. Seymour had asked, rather drily, how many of the matters discussed at the conference had not been investigated by industrial psychologists twenty-five years ago.

So some extent, Mr. Seymour's question was answered in a later contribution by the present writer, who made comparisons between the first ten years of ergonomics and the first ten years of occupational psychology. The chief differences seemed to lie in the wider scope of occupational psychology. It encompassed problems of 'fitting the man to the job' as well as problems of 'fitting the job to the man'; and it studied attitudes as well as skills. Dangers arising from narrowing the range of the industrial problems taken into account were illustrated by Dr. J. J. O'Dwyer, of Unilever, who spoke about informal groups in industry, and the importance of perceiving and using them; and by Mr. R. M. McKenzie, of the Social Sciences Research Centre at Edinburgh, who showed—entertainingly—how social factors could keep a worker's output well below his potential.

What of the next ten years? If the members of council of the Ergonomics Research Society have not

yet drawn their conclusions from their experience of the first decade, they might think about covering the following points in their discussions. First, there is perhaps little to be gained by making ergonomics out to be a science. It is a kind of conglomeration—not even a compound—of technologies ; and it might be a good thing for it to continue like that. Possibly the Society should be content to serve the same kind of admirable purpose as the British Nuclear Energy Conference, which pulls in people from a number of fields without seeking to detach any of them from their primary allegiances.

Secondly, there is undoubtedly a lot to be said for the running of courses of lectures and practical work for people, from a variety of levels and types of work, who are faced with 'ergonomic' problems. The short Bristol course outlined by Dr. S. Griew seems sound in its aim, which is to put across useful facts about the structure and functioning of the human body ; to show where more can be found ; to explain and demonstrate experimental approaches to problems of equipment design ; and to suggest that 'fitting the man to the job' and 'fitting the job to the man' should often be tackled together.

Thirdly, however, there is perhaps room for far more stress on the need to look into, learn about and teach people about, individual differences, especially on the psychological side. Mr. Stockbridge's *cri-de-coeur* ("Individual differences are a frantic nuisance. . . . If only we had a standard man . . .") brought out this need. Some workers in this field are clearly tempted, not merely to wish that there were such a creature, but to assume that there is. Mr. Welford seemed almost to succumb when he spoke hopefully about the discovery of 'standard times' for mental operations, and more particularly when he hinted that one had been run to earth in Antwerp, where telephonists had consistently coped with five bits of information a second. Dr. Conrad, commenting on this later, unwittingly challenged Mr. Welford by revealing that Norwich girls could manage seven without any trouble.

Discrepancies like this cannot really be met by jocular references to the possible existence of 'national' differences. They must be taken seriously. Could they arise from differences in the kinds of people being guided into and selected for the work in different places or at different times ? Or from differences in training arrangements ? Or from differences in methods of work adopted ? Or from differences in equipment ? Or from differences in working conditions of several kinds, including the physical, the social and the financial ? All these and other possibilities should be explored.

But here we encounter two important snags. Can exploration of the kind needed be carried out satisfactorily on the tiny, homogeneous, doubtfully relevant groups often used by researchers in the vast field of ergonomics ? And can it be tackled adequately by researchers whose devotion to 'precise' measurement is such that they are inclined either to forget or to ignore deliberately the existence of possibly influential factors which lie beyond the reach of their cherished clocks and counters ? The state of play in ergonomics ten years from now may depend a good deal on the answers the Council of the Ergonomics Research Society gives to these two questions.

Alec Rodger

DISTRIBUTION OF SCIENTIFIC PUBLICATIONS IN UNDER-DEVELOPED COUNTRIES

THE Scientific Publications Council, which has recently been formed, includes the editors of twenty scientific journals and the authors of a number of scientific books. It was started by a group of scientists who felt the need for an independent body that could uphold the interests of scientific authors and editors in working for higher standards in the publication and distribution of scientific books and journals. The Council is intended to provide a means for scientific writers and editors to maintain contact with each other and exchange views with others concerned in scientific publication in Great Britain and overseas : it provides a forum for the discussion of matters of mutual interest and a means of obtaining advice in technical and legal matters relating to publication. It is intended that the Council should work to establish good relations between scientific writers and publishers, and co-operate in setting up agreed standards that are acceptable to scientists and publishers alike. The officers of the Council are appointed for a term of three years ; Prof. G. W. Harris is chairman of the Council and Dr. D. Richter, Neuropsychiatric Research Unit, Whitchurch Hospital, Cardiff, is honorary secretary.

At a meeting of the Scientific Publications Council held on April 10 at the Ciba Foundation, London, Mr. John Hampden (British Council) opened a discussion on the distributions of scientific publications in the under-developed countries. He described the difficulties experienced in many countries in obtaining British books and periodicals. In Asia and Africa there is rapidly growing up a new literate class which wants to read, but in many places no British publications are available. In some places it is hard to persuade any bookseller to obtain them, as the necessary currency authorization is difficult, expensive or impossible to get, and the profit is small. On the other hand, there is an abundant supply of State-subsidized cheap editions from the U.S.S.R., China and also the United States. The English language is now an international possession. The students wanting books are the scientists, professional men and leaders of the future, and it is bound to affect their future reading and outlook if the only books they can get are not British.

Currency shortages are mainly responsible for the situation in some countries, including Poland, Turkey, Israel, Pakistan and Indonesia. How can people in these countries buy British books and periodicals if they have no sterling to pay for them ? Other difficulties in some countries include the shortage of bookshops stocking British books and the lack of libraries where British publications can be seen. The difficulty is especially acute for scientific

and medical books, which are needed by specialists. In the Western countries where libraries are largely taken for granted, it is hard to realize that in many places a student may have access to very few books which he does not buy for himself; and the cost of one book may be more than a whole month's salary. In many places it is even impossible to get up-to-date lists of British books and their very existence is in danger of being forgotten.

The Americans have got round the currency restrictions by export schemes in which the publishers are paid directly by the Government, so that the importing countries need no dollars to pay for books. This was originally a British idea (invented by Sir Stanley Unwin) which the Americans have adopted. British text-books have been deservedly popular in Asia and Africa for many years, but there is a serious danger that they will soon be swept out of some important markets. Mr. Hampden said we are not afraid of fair competition, but British publications cannot compete with exports heavily subsidized by foreign governments. It is a matter of considerable concern to those familiar with the situation that the journals of many British learned societies are not organized as the book-publishers are to increase their sales overseas, and it looks as though these journals are getting seriously left behind. It is essential that more information about British scientific books and journals should be made available overseas. The British Council is doing all it can to spread this information abroad.

Dr. P. Rosbaud said that the cultural importance of scientific books has only recently been appreciated in Great Britain. The export of scientific and technical books is not only of benefit to the book trade but also has a far-reaching influence on education and commerce in general, so that it pays high political dividends as well. One of the main factors influencing distribution abroad is the cost. Why are scientific books so expensive in comparison with other books of similar size, and where do all the profits go? For a typical book of 250 pages selling at 30*s*. the publisher may hope to sell 3,000 copies and break even at 2,400—if he sold less than 2,400 he loses; if more, he gains. For such a book the printer's estimate may be 8*s*. a copy, including the cost of correction, blocks and paper. There is little to be saved by using paper of cheaper quality. The publisher's overheads might be 2*s*. 6*d*., advertising 2*s*. and the author's royalty at 12½ per cent would be 3*s*. 9*d*. Allowing 33 per cent, or 10*s*. for the bookseller, that left the publisher with only 3*s*. 9*d*. as his profit. In any sales in the United States the publisher may need the services of an American distributor who would ask 50–60 per cent of the selling price, and the British publisher would also have to pay the additional cost of freight. There is the alternative of selling a small number of books at a high price or a larger number at a lower price, as with text-books. Text-books have got to be cheap, and this might be achieved by bringing out a large first issue of 5,000 copies without profit and then making a profit on subsequent issues. It was not right that the author should ever be asked to waive his royalty, which was little enough anyway: no reputable publisher would ever ask that. In the publication of scientific journals great patience might be needed before a profit could be made. Sir Richard Gregory had told Dr. P. Rosbaud that *Nature* took more than twenty years before the circulation was sufficient for it to make its first profit. Publishing a journal is like cultivating a garden in which one must wait a long time for the harvest. As the circulation increases and the journal gradually becomes more profitable, the publisher can pass some of this on to the consumer by reducing the price or increasing the size. Scientific journals could be made considerably cheaper by including advertising space. Otherwise, the only way of reducing the cost is to increase the circulation. Where publishing is a government monopoly, as in the U.S.S.R., books and journals can be produced at a very low cost; but there are objections to this practice. Such publications may have plenty of room for the Lysenkos, but not for the Vavilovs and Pasternaks, and the results are tragic. There is an urgent need for the British Government to develop an effective export scheme in answer to the floods of cheap State-subsidized publications from other countries.

The chairman, Prof. G. W. Harris, asked how scientists in Britain could best help in getting scientific books and journals distributed in the countries that need them. Mr. Hampden thought that the Scientific Publications Council might help in bringing the problem to the notice of the learned societies. Dr. F. N. L. Poynter described the work of the Wellcome Historical Medical Library in collecting scientific books and medical journals and distributing them in under-developed countries abroad. He thought it would be helpful if the existence of a voluntary distributing centre of this kind were made more widely known.

MAPPING VEGETATION

An international symposium on mapping vegetation was held during March 23–26 in Stolzenau/Weser, in the Federal Republic of Germany. This gathering of 112 scientists from sixteen countries, including Japan and the United States of America, was organized by the head of the Bundesanstalt für Vegetationskartierung, Prof. R. Tüxen (Stolzenau), on behalf of the International Society for Plant Geography and Ecology.

The rapid progress of phytosociology (phytocenology) in this century, especially during the past three decades, has made feasible the scientific mapping of vegetation based upon well-defined plant communities. In view of recent advancements in this field, an international meeting to facilitate exchange of views, personal contacts and assessment of new future developments was very timely.

Mapping of vegetation at the Bundesanstalt für Vegetationskartierung (formerly Zentralstelle für Vegetationskartierung des Reiches) began in 1931 for the Nature Conservancy Service in Hanover. Then, as now, the mapping of vegetation was preceded by extensive field work on existing plant communities in the respective area by the methods of the Zurich–Montpellier school of phytosociology. In addition to fundamental research on plant communities, their

ecology and distribution, a large variety of applied research programmes have been completed which involved mapping actual and potential vegetation for various practical aims in agriculture, forestry, water supply, transport and nature conservancy. At present, a large programme of vegetation mapping has been undertaken for the West Germany railways, in which the vegetation along about 30,000 km. of its railway network will be mapped to provide a sound basis for certain practical measures. For some time the Institute has been working on a complex research problem concerning the relationship of a particular plant community to the soil profile, and members of the symposium were much impressed by the exhibition of about 300 large, well-prepared soil profile mounts from north-west Germany. In solving many complex problems on vegetation for Germany, this independent research institute has become indispensable to other neighbouring countries in Europe, which face similar problems of a fundamental or applied nature. It is hoped that recent progress will be maintained and its sound future development preserved.

The papers presented at the conference may be subdivided into three major groups: (*a*) methods, (*b*) recent advances, and (*c*) applications.

(*a*) *Methods.* The importance of fundamental principles, methods and aims is of much concern in any mapping of vegetation. In his introduction, Prof. M. Schwickerath (Aachen) referred to the significance of 'association diagrams' in mapping, by illustrating this with examples of the *Violon calaminariae* and *Sphagnum* associations. Prof. A. W. Küchler (Kansas) explained the compilation of a small-scale vegetation map of the United States and the various problems involved. Prof. A. Scamoni (Eberswalde) presented the new vegetation map of the East German Republic on a scale of 1 : 1,000,000 and indicated the principles applied in this work. Prof. I. Horvat (Zagreb) referred to the basic considerations in applying higher units of vegetation while outlining the main features of vegetation in Yugoslavia. Prof. A. Noirfalise (Brussels) reviewed the aims and methods used in mapping the vegetation of Belgium; and those for recording marine biocenoses of the sea bottom off the coasts of France were outlined by Dr. R. Molinier (Marseilles). On this topic Dr. Molinier gave a lecture illustrated by excellent colour slides of underwater scenes taken on various trips in the Mediterranean. Prof. H. Gaussen (Toulouse) explained the choice of colours in cartography, illustrated by his excellent bioclimatic maps of Africa and South America. The following five papers from the Bundesanstalt für Vegetationskartierung dealt with the main principles, methods and techniques adopted there. Dr. W. Trautmann discussed his field experiences, and Dr. W. Lohmeyer assessed the value of aerophotography. Prof. R. Tüxen stressed the importance of mapping potential vegetation, which is more advantageous in forestry than the actual vegetation. Dr. K. Walter spoke on introductory courses in phytosociology held in Stolzenau, and Dr. A. Wenzel explained techniques in cartography employed there.

(*b*) *Recent advances.* The advances made in recent years in phytosociology in various countries and the value of vegetation maps in related fields of science constituted the second topic of the symposium. Dr. A. E. Apinis (Nottingham) stressed the relationships of soil micro-organisms to higher plants and the value of vegetation maps for the fundamental research in soil microbiology. Prof. F. Major (Davis, California) outlined the basic approach to vegetation necessary for their mapping on a scale of 2 in. to 1 mile, while Mr. A. Miyawaki (Yokohama) dealt with the occurrence in Japan of snow-patch communities similar to those of the European mountains. Mr. S. Bertovic (Zagreb) described vegetation mapping in Croatia and in other parts of Yugoslavia, while Dr. A. O. Horvat (Pecs, Hungary) presented a detailed map of forest phytocenoses of the Mecsek Mountains in southern Hungary, and Dr. R. Neuhäusel (Brno) spoke on mapping natural vegetation in Moravia. Mr. I. S. Zonneveld (Sleeuwijk, Holland) explained the mapping of both alluvial soils and vegetation in the tidal fresh-water area of the Rhine delta, combining the direct field method with that of aerial photography. Mr. Doing Kraft (Wageningen) is using physiognomic characteristics in recording the unstable dune vegetation near Harlem. Dr. J. Tüxen (Stolzenau) spoke of the application of vegetation maps in solving problems in the historical investigation of rural landscape, while Prof. J. Schmithüsen (Karlsruhe) emphasized the significance of vegetation maps of various scales in phytogeography and other related sciences.

(*c*) *Applications.* The variety of purposes to which the mapping of vegetation may be applied was revealed by the following papers, which were illustrated by a number of excellent large-scale maps. Prof. A. Matuszkiewicz (Warsaw) spoke of developments in phytosociological mapping in Poland and its present applications. The possibilities of ecological and phytosociological mapping for applied purposes was discussed by Dr. G. Long (Montpellier). Prof. P. Fukarek (Sarajevo) outlined the application of vegetation maps in the forestry work of Bosnia and Herzogowina, and Prof. M. Wraber (Ljubljana) explained the use of the general map on a scale of 1 : 100,000 of potential natural vegetation of north-west Yugoslavia as a basis for re-afforestation work on the degraded Karst and Flysh areas. The paper of Mr. K. Mraz and Mr. V. Samek (Prague) on certain problems on the cartography of vegetation and its applications in forestry was read by Prof. R. Tüxen.

The mapping of vegetation is regarded as the best approach to solving problems of water relations in various plant communities. On this aspect Prof. H. Wagner (Vienna) reviewed the mapping of vegetation for certain purposes in connexion with hydroelectric works in Austria, while Dr. K. Meisel (Stolzenau) spoke on its importance for the assessment of damage to vegetation due to water. Dr. P. Seibert (Munich) showed the application of phytosociological mapping of 'Pupplinger Au' near Munich to the water economy service there, and an assessment of damage due to salt water to meadows of the Werra Valley was given and its prevention planned on the basis of a vegetation map described by Dr. B. Speidel (Bad Hersfeld). According to Mr. Th. A. de Boer (Wageningen) mapping of various grasslands in Holland has been combined with soil mapping to provide an efficient agricultural advisory service in certain areas. Prof. L. Steubing (Giessen) found the regular occurrence of certain grassland communities in areas where wind-break hedges are common. The importance and practice of mapping Alpine grasslands in Oberengadin was demonstrated by Dr. F. Marschall (Zurich). The two last papers dealt with certain aspects of nature conservancy. Dr. E. Preising (Hanover) reviewed mapping of vegetation in relation to problems of

nature conservancy and landscape, and Mr. P. Tideman (Doorwerth, Holland) found direct mapping combined with aerial photography very useful in the management of the various protected areas in Holland.

Two decisions of general interest may be briefly mentioned. (1) A permanent commission was formed for the preparation of a vegetation map of Europe, with Prof. R. Tüxen (Stolzenau) as chairman and the following members: Prof. J. Braun-Blanquet (Montpellier), Prof. L. Emberger (Montpellier), Prof. I. Horvat (Zagreb), Prof. A. Noirfalise (Brussels) and Prof. B. Pawlowski (Cracow). (2) The following resolution was adopted for submission to Unesco and all the member Governments concerned: "The vegetation of the Earth represents the vital productive potential upon which all life depends. Therefore, the comprehensive study of vegetation is of the utmost importance, and for this purpose the combination of ecological, phytosociological and cartographical methods are required.

"The present-day methods of mapping vegetation greatly enlarge our fundamental knowledge of plant communities, their development and distribution as well as providing a deep insight into their environments. In applied phytosociology the mapping of vegetation constitutes a solid basis for assessment of habitats, for utilization of vegetation, and for the evaluation, or even the forecasting, of any change or damage to vegetation by erosion, wind, water and other natural or human factors.

"It is suggested that no large-scale technical measures should be planned or carried out which may influence the vegetation or landscape without first mapping the vegetation prior to the respective technical measures being put into effect."

A. E. Apinis

BIOLOGICAL FIBRES

IT is some time since the X-ray Analysis Group of the Institute of Physics has met to consider biological fibres, so that the conference in Leeds held during April 17–18, even if only partly devoted to fibres, was very welcome. It is, however, symptomatic of the present place of specialist techniques (even if they are as well established as X-ray diffraction) in such fields as the study of fibre structure, and perhaps even more of the trend of development of the corresponding specialist groups, that of the seven papers presented on this occasion only two could be classed as predominantly crystallographic in content, whereas in two others, which dealt respectively with infra-red absorption and the electron microscope, X-rays had no more than a casual mention. That these other techniques are now essential partners with X-ray diffraction in research on fibre structure was emphasized by the part they played in the other three papers. Nevertheless, in this account attention will be confined chiefly to topics which are more closely associated with the nominal activities of the Group.

The successful study of the cellulose fibre by X-ray analysis set a fashion which is evidently, even after more than thirty years, not yet outmoded. This fibre is still presenting fundamental crystallographic problems for investigation; for example, it seems still to be possible to argue about whether the cellulose chain molecules are all oriented in the same sense, or form two antiparallel systems. D. W. Jones and his colleagues (British Rayon Research Association) are non-committal about it in their discussion of cellulose I, but favour alternation in cellulose II. Prof. R. D. Preston (Leeds) suggests that in cellulose I alternation is unlikely, basing his argument on the idea that growth is by end-synthesis. His conclusion was, however, criticized in discussion, and also seems impossible to reconcile with the almost universal acceptance of alternation in cellulose II, although whether this is necessary or merely a convenient dogma is not at all clear. It does seem reasonable to expect that, if chain polarity is of any significance at all, the same type of arrangement will be present in both modifications.

Another controversial feature is the type of hydrogen bonding, about which there are two schools of thought respectively accepting or denying the presence of diagonal hydrogen bonds (specifically perpendicular to the [101] normals in the Meyer and Misch cell). The orthodox, among them the British Rayon Research Association team, agree with Meyer and Misch at least on this one point, that the hydrogen bonds are parallel to the *a*-axis of the unit cell. Both schools have recently adduced infra-red absorption results in favour of their arguments, creating further confusion for the non-specialist.

Agreement does seem to be reached on one point, that there is more than one cellulose I structure; the eucellulose (Preston) or type *A* cellulose (Marrinan and Mann) of *Valonia* must, one supposes, be cellulose I proper; ramie, the typical type *B* cellulose, is classed with most of the other plant fibres as yielding on hydrolysis, besides glucose, other sugars which are to be regarded as contaminants.

Some fibrillar aspects of the fine structure of cellulose also received attention. Preston believes that the microfibrils retain their identity when surrounded by incrustants in the cell wall, and that their surface structure is in some way responsible for the electron diffraction patterns which he and his colleagues have obtained from metal–cellulose complexes.

The application of X-ray analysis to the problem of the structure of silk fibroin is nearly as old as its application to cellulose, and we have been accustomed for a long time to distinguish between the structures of the two principal silks of commerce, domestic and tussah. It is now clear that these are but two of a family of at least six fibroins produced by various members of the orders Lepidoptera and Araneae; the silks produced by some fifty species were examined by J. O. Warwicker (Shirley Institute, Manchester) to establish this. A disturbing observation is that there appears to be no strict correlation between the crystallographic type of the fibroin and the biological classification of the producing species. Structurally, the fibroins differ in the separation of the hydrogen-bonded pleated sheets of polypeptide

chains; this distance may be as small as 9·3 A. (*Bombyx mori*) or as large as 15·7 A. (*Nephila senegalensis*). In fibroins with the larger inter-sheet separations amino-acid residues with long side-chains must occur in the crystalline regions. In view of the importance of this idea, which has always been virtually rejected before in theories of fibroin structure, further details of the relevant chemistry would be welcomed.

The cross-β configuration, so extensively studied in the keratin–myelin–elastin–fibroin group of fibrous proteins, has always been something of a puzzle because of the difficulty of obtaining a good X-ray diffraction diagram. That a solution of the problem should now be given in terms of a structure closely allied to a fibroin rather than to keratin is one of those oddities which sometimes arise in fibre structure research. K. D. Parker and K. M. Rudall (Leeds) have found, in fact, a cross-β fibroin in the egg-stalks of the lacewing fly; it gives a remarkably good X-ray diffraction pattern the interpretation of which leaves no doubt that the fibroin chain-molecules are arranged in long folds transverse to the fibre-axis. From this folded configuration the chains can be brought into the parallel-β state by stretching the material to about six times its initial length. This change is regarded as a true intramolecular transformation like the α–β transformation in keratin, but differs from the latter in that so far no success has followed attempts to reverse the change.

Heavy-metal staining techniques are of great importance in electron microscopy, and are now being successfully employed in studies of the microfibrillar texture of keratin fibres. Work is going on in various centres to correlate such electron microscope observations with the older X-ray results that mercury, for example, can modify the intensities of the equatorial 'reflexions' at approximately 80 A., 45 A. and 27 A. in keratin. H. J. Woods (Leeds) reported that staining with mercuric acetate also affects the wide-angle diffraction pattern, when corrections are made for increased absorption due to the metal. In an attempt to account for the small-angle 'reflexions' in terms of a model of uniform microfibrils it is found that conventional Fourier transform methods for obtaining the radial distribution of interfibrillar vectors are inapplicable, and the direct method of calculating the intensity from an assumed radial distribution often results in a negative intensity. In the discussion it was suggested that there might be a failure of the conventional theory for systems so nearly close-packed as those considered, but it now seems more likely that the difficulty is due to the fact that for such systems the radial distribution must be so nearly determined by geometry that the use of an arbitrary distribution may well be physically unsound. J. Sikorski emphasized that the electron microscope results so far tell us only about the details in para-cortical cells; the size and packing of the microfibrils in the ortho-cortex may well be different. H. J. Woods

THE SMITHSONIAN INSTITUTION

REPORT FOR 1957–58

THE report of the Smithsonian Institution for the year ended June 30, 1958*, covers the 112th year of the Institution and includes the report of the Secretary and the financial report of the Executive Committee of the Board of Regents, together with reports of branches of the Institution and on the library and publications. The Institution has now nearly 51 million catalogued objects in its collections, and visitors to all its branches totalled more than 10·36 million. Field work during the year included the excavation of the Welcome Mound along the Ohio River in West Virginia; continued field investigations of the bird-life of the Isthmus of Panama, and the mammal survey of Panama; a long-range programme designed to solve the stratigraphic sequence in the Glass Mountains; and extensive palæontological work in Oklahoma, Texas, New Mexico and Colorado.

Systematic researches by the staff of the Bureau of American Ethnology included Eskimo and arctic studies, field-work in South Carolina, among the New York Seneca and in Florida, and excavations at Russell Cave, Alabama. The director of the Bureau continued also as director of the River Basin Surveys, which continued its programme for salvage archæology in areas to be flooded or otherwise destroyed by the construction of large dams. By June 30, 1958, 254 surveys and excavations had been made in twenty-nine States and 4,889 archæological sites located, of which 997 had been recommended for excavation or limited testing; by the end of the year, 388 sites in fifty-two reservoir basins in nineteen States had been partly or extensively dug.

The Smithsonian Astrophysical Observatory continued to work along the four principal lines of solar astrophysics, meteors, the satellite tracking programme and studies of the upper atmosphere, in which methods based on celestial mechanics were developed for inferring the density of the upper atmosphere from the motions of artificial Earth satellites, and a theoretical study of the nature and thickness of the lunar dust layer was completed. Its Division of Radiation and Organisms continued studies on photomechanisms in plants, with special emphasis on growth responses controlled by low levels of red and blue radiant energy. Studies of the interaction of gibberellin, kinetin and cobalt with the photo-process indicate that there is no direct interaction between red irradiance and the added substances, although all these materials modify the final growth response. Studies were continued on the effects of radiant energy on the biosynthesis of protochlorophyll in leaves of higher plants grown in the dark, and in a study of biochemical changes involved in the development and maturation of the chloroplast

* Smithsonian Institution. Report of the Secretary and Financial Report of the Executive Committee of the Board of Regents for the year ended June 30, 1958. Pp. x+232+14 plates. (Washington, D.C.: Government Printing Office, 1958.)

of higher plants, some progress was made in isolating intact proplastids from leaves grown in the dark.

Good progress is reported in locating a site for a new building for the National Air Museum, to which 193 specimens in 52 accessions were added during the year. The National Zoological Park, to which 1,411 animals were added during the year, now totals 2,316 individual specimens, and visitors exceeded 4 million, while those to the Canal Zone Biological Area totalled 570, of whom forty-three were scientists, students or observers using the station for scientific work, particularly in wild-life observation, plant and insect studies and photography. The International Exchange Service handled 1,094,798 packages, including 63 full and 43 partial sets of United States official publications in exchange for official publications sent by foreign Governments for deposit in the Library of Congress. The Library received 53,274 publications during the year, and arranged 128 new exchanges. Its holding at the end of the year totalled 974,893, including 586,722 in the Smithsonian Deposit at the Library of Congress. The report includes a list of the 81 new Smithsonian publications issued during the year.

EFFECT OF NITROUS ACID ON TOBACCO MOSAIC VIRUS: MUTATION OR SELECTION?

By F. C. BAWDEN, F.R.S.

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GIERER and Mundry[1,2] claim that treating preparations of tobacco mosaic virus or of its nucleic acid with nitrous acid *in vitro* causes mutations. Indeed, they state that their "experiments show that replacement of one single NH_2-group by one OH-group *in vitro* can change the genetic character of the whole TMV-RNA molecule"[2]. The genetical implications of this statement are so great that, before accepting it, there is more than usual need to ensure that their experiments could have no other interpretation. What their results show is that, when tobacco mosaic virus is treated with nitrous acid, its infectivity, as measured by the numbers of local lesions formed in one tobacco variety, Xanthi, decreases, while the number of necrotic lesions produced in another variety, Java, increases. Xanthi forms necrotic local lesions with all the usual strains of tobacco mosaic virus, whereas Java forms them with only some and not with the type strain.

These results are readily reproducible. Table 1 shows two experiments with the Rothamsted type culture of tobacco mosaic virus; in one, inoculations were made to Xanthi and Java and in the other to *Nicotiana glutinosa* L., which like Xanthi gives necrotic local lesions with the type strain, and to Judy's Pride, a variety of White Burley, which, like Java, does not. The starting preparation, like those used by Gierer and Mundry, produced a few necrotic lesions on Java and Judy's Pride. There is nothing unusual in this, for all bulk preparations of tobacco mosaic virus contain a mixture of strains. However, this being so, it is obviously necessary to consider whether the change in behaviour of the preparations towards the different plants during inactivation by nitrous acid could simply reflect some form of selection from a mixed population of strains. Gierer and Mundry state that this possibility is excluded because the total number of lesions produced on Java increases and not simply the ratio of lesions on Java to those on Xanthi. They therefore conclude that the number of particles able to cause necrotic lesions on Java must have been increased by exposure to nitrite. But must it? Their conclusion rests on the assumption that strains do not interact and that one will always produce its characteristic effects regardless of how much of other strains is present.

Table 1. NUMBERS OF NECROTIC LESIONS PRODUCED BY DIFFERENT *Nicotiana* SPECIES AND VARIETIES WHEN INOCULATED WITH TOBACCO MOSAIC VIRUS TREATED FOR VARIOUS TIMES WITH NITROUS ACID

Time (hr.)	Numbers of necrotic lesions per leaf			
	Exp. 1		Exp. 2	
	Xanthi	Java	*N. glutinosa*	Judy's Pride
0·0	300	0·5	350	2
0·5	250	9	300	12
1	122	24	210	20
2	98	26	130	28
4	33	12	60	33
20	6	0·5	10	15

Tobacco mosaic virus at 4 mgm./ml. was incubated with 1 *M* sodium nitrite and 0·25 *M* acetic acid at *p*H 4·1 for the times stated, when samples were diluted 1/10 in *p*H 7 phosphate buffer and used as inocula. Xanthi and *N. glutinosa* give necrotic local lesions with the type strain of tobacco mosaic virus, Java and Judy's Pride do not.

Table 2. NUMBERS OF NECROTIC LESIONS PRODUCED BY DIFFERENT *Nicotiana* VARIETIES AND SPECIES WHEN INOCULATED WITH MIXTURES OF TOMATO AUCUBA AND TOBACCO MOSAIC VIRUSES

Inoculum	Numbers of necrotic lesions per leaf			
	Exp. 1		Exp. 2	
	Xanthi	Java	*N. glutinosa*	Judy's Pride
Aucuba alone	95	240	66	75
Aucuba in TMV 20 mgm./l.	130	180	128	60
Aucuba in TMV 200 mgm./l.	380	24	350	14
Aucuba in TMV 2 gm./l.	500	2	400	4
TMV 2 gm./l. alone	500	3	450	2

The tomato aucuba mosaic virus was used at 10 mgm./l. With the high concentrations of tobacco mosaic virus (TMV) the lesions on Xanthi and *N. glutinosa* were too many to count accurately.

There is much evidence at variance with this assumption. For example, it has long been known that infection of a plant with one strain of tobacco mosaic virus prevents other strains from producing their characteristic effects[3] and that adding type tobacco mosaic virus to inocula of strains that produce necrotic lesions in Judy's Pride tobacco decreases the number of lesions they produce[4]. One such strain is tomato aucuba mosaic virus, and Table 2 shows how mixing this with various amounts of tobacco mosaic virus can affect the number of necrotic lesions formed on Java and Judy's Pride. Decreasing the amount of tobacco mosaic virus reproduces the phenomenon, which in treatments with nitrite Gierer and Mundry

say can only be attributed to mutations, of decreasing the numbers of lesions produced on Xanthi and *N. glutinosa* while the numbers on Java and Judy's Pride increase. Numbers of necrotic lesions, however, do not tell the whole story, for mixing aucuba mosaic virus with tobacco mosaic virus alters the type of lesion produced, especially on Java. Aucuba mosaic virus alone produces distinctive, reddish-brown circles that may reach a diameter of 0·5 cm. None of the lesions recorded in Table 2 as formed by inocula containing the larger amounts of tobacco mosaic virus was of this type, but all were white spots and flecks of various sizes. With smaller amounts of tobacco mosaic virus, the lesions were more variable; some were all white, but others had small reddish-brown centres, and some approximated to true aucuba type. More of the last type occurred as the concentration of tobacco mosaic virus decreased.

Similarly, when mixtures containing 4 mgm./ml. tobacco mosaic viruses and 20 mgm./l. aucuba mosaic virus were diluted 1/10 in *p*H 7 phosphate buffer and inoculated to Java, only white lesions were formed, whereas a range of types was produced after incubation with nitrite. The first brown lesions to appear were small, but as the treatment continued they became more typical of the aucuba type. It is highly unlikely that adding aucuba mosaic virus to the starting preparation directed any mutations caused by nitrite towards characters peculiar to aucuba mosaic virus, and a more reasonable interpretation is that the residual aucuba mosaic virus became increasingly able to make itself evident as the concentration of infective tobacco mosaic virus decreased. This interpretation does not demand that aucuba mosaic virus should be more resistant than tobacco mosaic virus to inactivation by nitrite, for the ability of the latter to obscure the presence of aucuba mosaic virus is not determined only by the proportions of the two. Concentrated tobacco mosaic virus will obscure proportionally more than will dilute virus; for example, whereas 2 gm./l. will obscure 20 mgm./l. aucuba mosaic virus, 0·2 gm./l. will not necessarily mask 2 mgm./l.

The fact that the obscuring ability of tobacco mosaic virus increases with increasing concentration may simply reflect one aspect of the well-known interference phenomenon, that infection by one strain makes cells resist infection by others. The more concentrated the tobacco mosaic virus, the more epidermal cells it will infect at inoculation and the fewer there will be for aucuba mosaic virus to multiply in unhindered. Indeed, the range of local-lesion types in Java produced by mixtures of the two may mean only that, in different parts of the leaf, different proportions of cells contain one or other of the two strains. However, it is equally possible that there are other interactions between the strains as they multiply, leading, perhaps, to genetic recombinations or phenotypic mixing. This could be decided only by isolating the viruses present in different lesions and testing their behaviour when transmitted to a range of plants. Whatever may be the mechanisms of the interaction between strains, there is no doubt that strains able and unable to cause necrotic lesions in Java tobacco do interact and that this interaction affects both the quantity and quality of lesions produced. The experiment recorded in Table 2 shows fewer local lesions on Java when aucuba mosaic virus was mixed with tobacco mosaic virus than when inoculated alone; but the mixtures sometimes produced more lesions, though no lesion was then of the aucuba type and all were white spots, rings or flecks. Obviously the interactions are complex, but the fact that they occur makes the counts of necrotic lesions produced by mixtures of strains valueless for indicating the numbers of particles present that are intrinsically able to cause necrosis in Java. There seems no reason to look further for an explanation of the action of nitrite in increasing the numbers of lesions produced by tobacco mosaic virus in Java than that, as the concentration of particles unable to cause necrosis decreases, so they interact less with those able to cause necrotic lesions.

The phenomena that suggest mutation come from interactions between infective particles; but there is also an interaction between virus inactivated by nitrite and active virus. Inactivation by nitrite is an effect on the nucleic acid, and inactivated virus particles still retain their physical and serological properties, as do those inactivated by ultra-violet radiation. Like virus inactivated by ultra-violet radiation[5], and like the protein produced when virus particles are disrupted by alkali[6], nitrite-inactivated virus inhibits infection by active particles, and the presence of 0·4 mgm./ml. of such inactivated virus will halve the number of lesions produced by tobacco mosaic or aucuba mosaic virus at 10 mgm./l. This inhibition could affect measurements of inactivation rates, for as the amount of inactivated virus increases so it will increasingly inhibit infections by the residual infective virus, the amount of which will thereby be increasingly under-estimated and preparations will cease to infect while they still contain potentially infective particles. The virus protein is likely to be responsible for the inhibition, so tests with nucleic acid preparations are probably free from this complication; it was with these that Mundry and Gierer[2] found that inactivation follows first-order kinetics. Their conclusion that changes in single NH_2-groups cause mutations derives from the observation that the numbers of necrotic lesions produced on Java at first increase linearly with time; but this need mean little more than that the dominating strain in their starting preparation inactivated according to first-order kinetics. That their starting preparation did contain strains already able to cause necrosis in Java is clear, and that these were interacting with other strains is strongly suggested by the fact that, when diluted 1/10, the number of necrotic lesions on Xanthi fell to one-fifth whereas the number on Java was only halved.

The isolations Mundry and Gierer[2] made from single local lesions in Xanthi also show their starting preparation was mixed. Most of the isolates made from 60 lesions produced by nucleic acid after 90-min. exposure to nitrous acid differed from type tobacco mosaic virus, whereas only 1 out of 65 isolates made from the starting preparation was obviously different. This fact they advance as further evidence that nitrite caused mutations; but as the treated preparation had lost more than 99 per cent of the initial infectivity, 99 times as many lesions should have been sampled from the untreated as from the treated preparation to make a proper comparison. Had 6,000 lesions been sampled, there is every reason to think that more than 100 isolates differing from tobacco mosaic virus would have been found, for the fact that one was identified for certain from 65 lesions suggests that at least 2 per cent of the particles in the starting material differed from type tobacco mosaic virus.

I have made no tests to see whether different strains differ in the rate at which they are inactivated by nitrite; but it is to be expected that they will, for strains have been found to differ in their susceptibility to inactivation by most other treatments. The obvious place to look for resistant strains is among those that survive at the tail end of an inactivating treatment, and all that is needed to explain the preponderance of variants after exposure to nitrite is to postulate that strains differ in their rate of inactivation. That the isolates when propagated continued to show their characteristic differences from type tobacco mosaic virus is interesting, but has no relevance to the problem of how they came to be genetically different from the type virus. Mutations no doubt reflect chemical changes in the nucleic acid, and there is no *a priori* reason why changes produced *in vitro* should not affect the genetic behaviour of viruses, but to attribute mutations to such changes requires more than demonstrating that the end-products of an inactivating treatment differ in behaviour from the bulk of the starting material; it requires demonstrating that chemical changes produced *in vitro* are perpetuated in the progeny of the particles.

I am indebted to Dr. A. Gierer for providing me with seeds of the tobacco varieties Xanthi and Java.

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CHARACTERS ASSOCIATED WITH PARASITISM IN GRAM-POSITIVE BACTERIA

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THE concept of parasitism in bacteria has been overshadowed by the more immediate problems of pathogenesis, so that, in standard bacteriological literature, the words parasite and pathogen are treated as if they were synonymous, and harmless parasites are inaccurately designated commensals. Parasitism, properly so called, is common among bacteria, especially of the Gram-positive group, and it is the purpose of this article to indicate certain interesting conclusions that are derived from a consideration of the characters associated with its occurrence.

Many members of the Gram-positive group are not, in fact, Gram-positive in their staining reactions, but nevertheless bear so close a resemblance to the other members of the group in every other respect that they must be considered to have lost this characteristic secondarily. In very many instances, these are parasitic representatives of mainly free-living families. An obvious example is *Neisseria*, a genus consisting of obligate parasites, many of which have lost all trace of Gram-positivity, while retaining characters of morphology, metabolism, antibiotic sensitivity, etc., that indicate a relationship with the Coccaceae. (Their description as obligate parasites refers to their normal mode of life, and does not exclude the possibility of growth in artificial culture.)

A second important character associated with parasitism is anaerobiosis. So far as I am aware, all truly Gram-negative bacteria are aerobic; the so-called Gram-negative anaerobes, such as *Veillonella*, *Fusobacterium* or *Bacteroides*, have obvious affiliations with Gram-positive families, and these also are obligate parasites. This combination of characters is well known in the facultatively parasitic clostridia, many of which are very weakly Gram-positive, whereas the aerobic, sporing bacilli, few of which are parasitic, are strongly Gram-positive. Anaerobiosis without loss of Gram-positivity is found in the parasitic *Actinomyces*. The streptococci would serve as examples, in view of their lack of catalase, but most species are aerobic by virtue of their insensitivity to hydrogen peroxide.

The third character associated with parasitism in Gram-positive bacteria, as indeed in animals and higher plants also, is loss of structural complexity; although the bacteria are exceptional in that they commonly undergo a reduction in the organs of distribution.

Thus, in respect of these various characters, there is quite often found to exist a series of forms connecting a Gram-positive, aerobic saprophyte of complex morphology, with a Gram-negative, anaerobic parasite of simple morphology:

(*A*) The free-living sarcinae are large and strongly Gram-positive, they are aerobic, and include representatives which, by virtue of their possession of flagella and spores, attest a recent common origin with the sporing bacilli. The facultatively parasitic micrococci and staphylococci are Gram-positive and aerobic, but smaller and devoid of flagella and spores. The parasitic *Neisseria* are aerobic, but Gram-variable or negative; and the *Veillonella*, in addition to these characters, are anaerobic and very small indeed.

(*B*) The free-living streptomyces are large and strongly Gram-positive, they are aerobic and they branch and sporulate very freely. The large oral leptotrichia are aerobic and Gram-positive, they branch freely and form very occasional chains of spores[1]. The classical type of *Leptotrichia buccalis* is microaerophilic and Gram-variable, it branches rather rarely and does not appear to form spores[1]. Fusobacteria resemble *L. buccalis* very closely in general morphology, but are very small, Gram-negative, anaerobic and do not branch. All the last three are obligate parasites, but they are progressively more difficult to cultivate, in the order given. The origin of the anaerobic, Gram-negative *Bacteroides*, which bears some resemblance to the fusobacteria, is probably similar.

(*C*) The true *Actinomyces* (a genus of oral parasites typified by *A. bovis*) resemble *Micromonospora* in their main morphological features, but are anaerobic or microaerophilic and structurally degenerate[2].

If the conclusions arising from these observations are valid, it would appear that the great majority of

parasitic bacteria of the Gram-positive group are descended from more complex, free-living ancestors. This is, of course, a biological commonplace, but systematic bacteriology has not yet fully recovered from the effects of placing a very undue emphasis upon the taxonomic characters of those common pathogens, usually members of parasitic genera, with which the majority of bacteriologists are, or previously were, most closely acquainted, without taking into consideration the possibility of such tendencies as have just been described.

The suggestion that structurally complex Actinomycetes are ancestral to simpler forms, and even to cocci, is not new[4]; but former hypotheses of this type have tended to suggest the sort of relationship that exists between the mycelial and oidial fungi, rather than a progressive degeneration of structure, associated with anaerobiosis or loss of Gram-positivity, and sometimes with both.

It is not, however, easy to understand how these bacteria are able to dispense with the production of catalase and of the nucleic acids of the Gram-complex[3], which appear to be essential, or very advantageous, to their free-living counterparts. In the case of the bowel-dwelling forms, it is possible that their environment protects them against free oxygen; but whereas neither *Clostridium*, *Bacteroides*, '*Lactobacillus bifidus*' nor *Streptococcus faecalis* produces catalase, the truly Gram-negative intestinal bacteria do so in every case. Nor is the alternative explanation, that the anaerobes of the mouth, for example, live in such close association with large numbers of other bacteria as to profit from their catalase production or oxygen utilization, any more satisfactory, since the oral flora consists very largely of anaerobes or non-catalase-producing aerobes, such as streptococci and lactobacilli. The animal tissues themselves are the only probable source of the enzyme.

The significance of the loss of the Gram-complex in so many parasites is almost beyond speculation, but it is at least possible that it indicates the availability, in an elaborate form, of nutrients, with the synthesis of which from simpler materials these nucleic acids are concerned, under less-favourable conditions.

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DEVELOPMENT OF *TRYPANOSOMA VIVAX* TO THE INFECTIVE STAGE IN TSETSE FLY TISSUE CULTURE

By Dr. WILLIAM TRAGER

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EARLY in the work on trypanosome diseases of man and animals in Africa, it was found[1] that cultures of trypanosomes could be obtained quite readily in blood agar media inoculated with infected blood and incubated at temperatures of 25–30° C. But at the same time came the disturbing finding that such cultures lost their infectivity as soon as they began to grow[1,2]. What was happening soon became clear: in the cultures there developed only the so-called midgut forms of the trypanosomes, the same forms which develop in the midgut of an infected tsetse fly and which Bruce[3] had shown to be non-infective to the mammalian host. In a suitable tsetse fly, however, the trypanosomes migrate to the salivary glands and proboscis, where they become transformed into infective forms[4]. Recently, Weinman[5] reported in a preliminary way that he had produced infection in mice with two cultures of *Trypanosoma rhodesiense* maintained in a medium with trehalose (concentration not stated). With this exception, infective forms of the African trypanosomes have not previously been obtained in culture. It seemed possible that these metacyclic forms might develop *in vitro* in the presence of surviving or growing tsetse fly tissue.

The gonads of female lepidopterous larvæ are the only insect tissue that has up to now given outgrowths of cells at all comparable to those obtained with vertebrate tissues[6–8]. Although mosquito tissues survived *in vitro* sufficiently well to support the growth of western equine encephalitis virus[9], they did not produce cellular outgrowths, nor have such outgrowths been obtained with tissue from other dipterous insects. The cultivation of tsetse fly tissue was therefore a problem of considerable intrinsic interest, quite apart from its bearing on the developmental cycle of trypanosomes. It is the purpose of the present brief report, however, to relate only the main results of the experiments dealing with the production of infective trypanosomes *in vitro*. The complete details of these experiments, together with full information on the tsetse fly tissue cultures, will be reported elsewhere.

Tissues of the fly *Glossina palpalis* were obtained from pupæ or young adults free from extraneous bacteria. Pupæ of known age (sent to me from the Kaduna Laboratory of the West African Institute for Trypanosomiasis Research through the kindness of Mr. W. MacDonald) were sterilized externally in White's solution (mercuric chloride, 0·25 gm.; sodium chloride, 6·5 gm.; hydrochloric acid, 1·25 ml.; ethanol, 250 ml.; distilled water, 750 ml.), rinsed in sterile water and dried on sterile filter paper in a Petri dish. Such pupæ, if kept for the required time in sterile vials with sand, produced bacteria-free adults. The pupæ or adults were dissected aseptically in a drop of culture medium. Fragments of tissues were explanted either in hanging drops or in a thin layer of fluid (0·3 ml.) on the bottom of a Porter flask closed with a silicone rubber stopper.

The culture medium (Table 1) supported initial outgrowths from, and differentiation of, several kinds of tsetse fly tissue. In one type of outgrowth, mitotic division of the cells was seen. To obtain cultures of trypanosomes, however, tissues were used which lived *in vitro* but showed limited or no outgrowth. These tissues were the alimentary tract and salivary glands of a late pupa or a newly emerged fly. To a

Table 1. PREPARATION OF THE CULTURE MEDIUM

*Solution A**	mgm./100 ml.
NaCl	90
KCl	300
$NaH_2PO_4.H_2O$	110
$MgSO_4.7H_2O$	370
$CaCl_2$	80
Glucose	150
Trehalose	50
1-Malic acid	50
α-Ketoglutaric acid	25
Succinic acid	5
Lactalbumin hydrolysate	1,000
Yeast extract ('Difco')	200

* Based in part on work of Wyatt (ref. 7) and Grace (ref. 8). Ingredients were dissolved in water redistilled in a 'Pyrex' glass still. *p*H was adjusted to 6·8 with 1·0 *N* NaOH. The solution sterilized through a 'Selas' 03 porcelain filter.

Solution B†	mgm./10 ml.
Reduced glutathione	200
Ascorbic acid	2

† Sterilized through ultrafine glass filter.

Final mixture. Mix 8 ml. of solution *A*, 2 ml. sheep serum, 0·5 ml. solution *B*.

In 1 ml. of the above mixture in a centrifuge tube, crush gently two sterilized 12-day-old pupae of *G. palpalis*. Centrifuge 15 min. at 2,000 r.p.m. The supernatant with the re-suspended fatty layer at the surface constitutes the culture medium.

hanging-drop culture was added a minute drop of blood or trypanosome concentrate from an infected animal. Continuous culture was achieved of all three species of trypanosomes tried: *Trypanosoma brucei*, *T. congolense* and *T. vivax*.

The most interesting results were obtained with *T. vivax*, a species never before cultured and which, in the tsetse fly, omits the midgut phase and develops directly to the infective forms in the proboscis. A first attempt at cultivation of this species in fly tissue culture, using washed trypanosomes from a heavily infected sheep, gave a negative result. In the second attempt, the only sheep showing trypanosomes on that day was one, infected by fly-bite nine months previously, which had survived the acute infection and now occasionally showed small numbers of organisms in the peripheral blood. A concentrate from this blood, in which only one trypanosome could be seen per low-power field, was inoculated to fly tissue cultures prepared two days previously. Two days later it was noticed that the temperature of the incubator (set for 28° C.) had gone up to 30° C. At this time large syncytial multiplying forms of trypanosomes were seen in the tissue cultures. From these a strain was established and maintained in tissue culture for three months. It was discontinued only because the work was brought to a close. Soon after its establishment the strain was successfully transferred to blood agar slants and is still being maintained in this way. Later experiments then showed that *T. vivax* could be started in culture only by following the conditions which had occurred quite fortuitously the first time, that is, using blood from the sheep with a long-standing chronic infection, inoculating the concentrate of trypanosomes to tissue cultures two days old, and—very important—incubating these at 30–32° C., not at 27–29° C. Once started, the cultures can be kept equally well at either the lower or the higher temperature, but they have mostly been kept at the higher temperature.

Four strains of *T. vivax* in tissue culture have been begun, three from the original sheep and a fourth from a new infection in a sheep inoculated with blood from the original sheep. The first two culture strains have been studied in some detail. There were present in the cultures numerous forms morphologically indistinguishable from the classical infective forms of *T. vivax* as seen in the proboscis of the tsetse. But five sheep inoculated repeatedly with such material and followed for more than a month failed to show trypanosomes in the blood. Two of the sheep did have a fever, one on the eighth and the other on the ninth day after intravenous inoculation of culture material, but no trypanosomes could be found.

It was then decided to test the ability of the trypanosomes in fly tissue cultures to survive at body temperature, which is lethal to the usual culture of trypanosomes on blood media. A three-day-old hanging-drop subculture of strain 2 of *T. vivax*, in culture for six weeks, was placed in a jar immersed in a water-bath at 38° C. On the following day the culture presented a mass of very active trypanosomes. The material was inoculated intravenously into a sheep. Exactly one week later, scanty trypanosomes were present in the blood of this sheep. They were readily identified as *T. vivax*. The sheep was positive again on the following day, with about three trypanosomes per field. This sheep first showed fever (105° F.) on the ninth day, the only day of fever it has had. At this time no trypanosomes could be found, and it has since remained negative except for the thirteenth day (1 trypanosome in 150 fields) and the eighteenth day (1 trypanosome in 40 fields). Thus, transmission from culture was accomplished.

Attempts at repetition of this success were immediately instituted. An interesting finding was that whereas some tissue cultures of *T. vivax* showed mostly dead or sluggish organisms after exposure to 38° C., others were very active, like the culture which produced infection. A clean sheep raised at the laboratory was inoculated with a culture of *T. vivax* which had numerous active trypanosomes after the one day at 38° C. This sheep showed a positive blood film and had a fever on the seventh day after inoculation.

These two successful transmissions from culture make it certain that a reproducible method is now to hand for obtaining infective *T. vivax in vitro*. This makes possible a detailed study of the factors responsible for the acquisition of the infective state by trypanosomes, a matter of significance far beyond its immediate application in the field of trypanosomiasis. The relatively light infections which seem to have followed the inoculation of cultured *T. vivax* suggest the possibility of the development of a practical method for immunization against the parasite, using attenuated but infective cultures. This possibility requires and deserves much further investigation.

The work summarized in the foregoing report was done while I was a visiting investigator at the West African Institute for Trypanosomiasis Research, and I thank Dr. T. A. M. Nash, director of the Institute, and Dr. R. S. Desowitz, in charge of protozoology there, for their kind invitation to work in their laboratories and for the facilities extended to me by them and their staff. Travel to Africa was made possible by a grant from the Rockefeller Foundation.

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LETTERS TO THE EDITORS

GEOPHYSICS

Disturbance in the Ionospheric *F*-Region following the Johnston Island Nuclear Explosion

ACCORDING to the newspaper reports, American scientists exploded hydrogen bombs near Johnston Island on August 1 and 12, 1958, at heights of 160 km. and 100 km. The Apia magnetic records (Lawrie, J. A., and Gerard, V. B., private communication) give times as 10:50 and 10:30 G.M.T. Some geophysical aspects of these explosions have been discussed by Cullington[1] and Kellog *et al.*[2].

Here we will describe one of the effects on the ionospheric *F*-region. We have 10-min. recordings over the period of the first event and 2-min. recordings over the period of the second event.

Prior to both events, ionograms at Rarotonga showed the normal undisturbed night *F*-region. On August 1, the ionograms 40 min. after explosion (zero plus 40 min.) showed a great increase in maximum electron density, and 10 min. later this had exceeded the recording limit of the machine. In the next 40 min. the electron density decreased rapidly and at zero plus one hundred there was no trace of the normal *F*-region, but above it at a base height of 560 km. was seen a layer the maximum electron density of which was roughly one quarter of the normal *F*-value. The increase at the maximum phase was to at least seven times normal. Another interesting characteristic was the gradual drop of fifty kilometres in height as the ionization decayed. Fig. 1 is a schematic diagram deduced from the ionograms.

On August 12, the disturbance in the *F*-region took longer to reach Rarotonga and was much less severe. A detailed true height analysis of these records confirmed the form deduced for the first event and ensured that no significant phases were missed. We will discuss only the first event.

In order to gain a better picture of the physical process we examined also the ionograms for Christchurch, 44° S., and Campbell Island, 53° S., and, through the courtesy of J. A. Lawrie and V. B. Gerard, the magnetic vectors which they had prepared for Honolulu, Palmyra Island, Fanning Island, Jarvis Island and Apia.

A characteristic movement among the magnetic vectors was identified with the passage of the *F*-region disturbance. The times of passage of the disturbance at the eight stations were then plotted against distance from the point of explosion (see

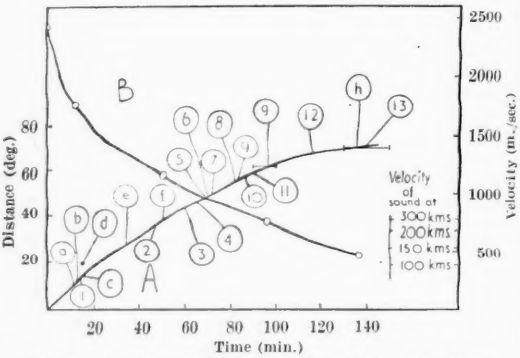

Fig. 2. *A*, Curve of delay times versus distance in degrees. *Observation sites. a*, Palmyra Island; *b*, Honolulu; *c*, Fanning Island; *d*, Jarvis Island; *e*, Apia; *f*, Rarotonga; *g*, Christchurch; *h*, Campbell Island. *Places where observations possible.* 1, Maui; 2, Adak; 3, Guam; 4, San Francisco; 5, Kokubanji; 6, Akita; 7, Wakkanai; 8, Townsville; 9, Yamagawa; 10, Brisbane; 11, Okinawa; 12, Baguio; 13, Hobart. *B*, Deduced velocity curve

Figure 2 *A*). The points lie well on the smooth curve except for Jarvis. This Station is on the dip equator, and there is reason for supposing that the time of its vector is advanced by several minutes. The corresponding velocities are shown in Fig. 2 *B*; values are only approximate because of limited data and time resolution.

The assumption made in drawing this smooth curve is that the velocity of propagation is independent of direction relative to the Earth's magnetic field. Attempts were made to reconcile the time delays with a field-dependent velocity but no reasonable pattern emerged. It seems, then, that the ionospheric disturbance is a by-product of a gaseous wave which is propagated at a velocity considerably above that of sound. For convenience we will refer to it as a shock wave.

It is not possible to account for the high value of electron density and its spatial distribution over Rarotonga merely by compression or even by the collection of all the electrons between Johnston Island and Rarotonga. Restraint by the Earth's magnetic field of the motion of charged particles precludes electrons coming from the nuclear event itself. Together with the complete disappearance of electrons after the disturbance, and the general appearance of the ionograms, these facts indicate electron production in the disturbance. We postulate ionization by collision and subsequent removal by

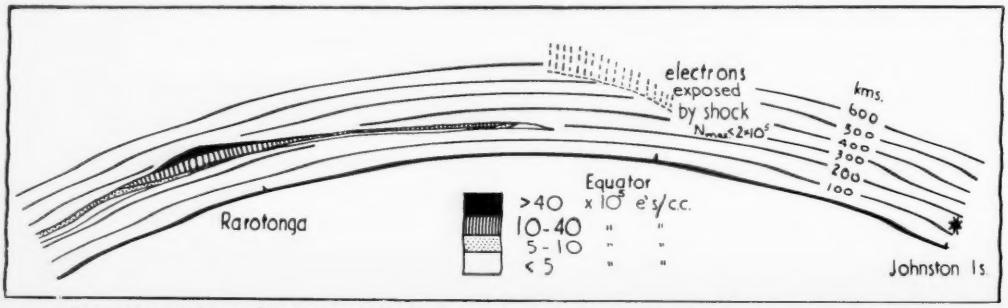

Fig. 1. The spatial form of the ionospheric disturbance as deduced from the Rarotonga ionograms for the event of August 1

attachment or re-combination in a region of relatively high gas pressure.

However, it does not seem possible that the main body of the gaseous shock wave travels in the region where the ionospheric disturbance is observed (200–550 km. height); for the compression ratios of a shock wave of this velocity are insufficient to produce the observed ionization, and, moreover, there is not enough gas at this level to explain the extended front. The apparent velocity at Campbell Island is below the velocity of sound at *F*-region height, while the characteristic form of the disturbance is maintained (increase in electron density with subsequent decrease in both density and height—no complete electron removal at this distance). Instead of a simple shock, we seem to have a supersonic surface wave of vertical extent much less than the wave-length, and the very high compression ratios producing the observed ionization are on its upper boundary. We do not feel competent at present to discuss this wave further.

As will be seen from Fig. 2 *A*, many ionospheric stations are in regions where they may have recorded the characteristic movements associated with the wave. Here is an ideal opportunity for international co-operation in an important study on atmospheric properties.

This work will be reported more fully in the *N.Z. Journal of Geology and Geophysics*.

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May 28.

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Geomagnetic and Ionospheric Phenomena associated with Nuclear Explosions

Nuclear explosions at high altitudes were carried out at Johnston Island (geographically 16·7° N., 169·4° W.; geomagnetically 14·3° N., 256·5° E.) at 10:50 G.M.T. on August 1 and at 10:30 G.M.T. on August 12, 1958[1]. Auroræ associated with these explosions were observed on both days at Honolulu[2] and Apia[3]. Apia auroræ on August 1 have been discussed by Cullington[3], Fowler *et al.*[4], Kellogg *et al.*[5] and Elliot *et al.*[6]. In this communication geomagnetic and ionospheric effects associated with these events are described from the International Geophysical Year obtained at various stations in the Pacific area and the American continent.

Immediately after the explosions, magnetograms showed sudden unusual variations at five stations in the central Pacific—Honolulu, Palmyra Island, Fanning Island, Jarvis Island and Apia. The variation at Honolulu had the form of an intense bay disturbance. The variation at the other four stations was somewhat like an unusually short-period magnetic storm (about 1 hr.) with a sudden commencement. Moreover, the sudden commencement at Apia showed an initial short reverse impulse (*SSC**) as reported by Cullington[3]. These geomagnetic effects occurred similarly for both events, although the magnetic storm on August 12 was smaller than that on August 1, probably due to the lower explosion height.

These associated geomagnetic storms indicated that counterclockwise circular electric currents were formed in the vicinity of Johnston Island immediately after the explosion, due to the dynamo effect caused by winds of charged particles which moved radially outward from the centre of the explosion. In other words, if the wind velocity due to the explosion in the 80–100 km. level became of the order of 100 m./s. and the electrical conductivity increased by the order of 10 times due to high-energy particles and X-rays, the associated counterclockwise electric currents in the vicinity of Johnston Island would have been sufficient to give the observed magnetic variations even at places 1,300–2,200 km. distant, such as Honolulu, Palmyra, Fanning and Jarvis Islands. The geomagnetic effects observed at Apia could have resulted from these circular electric currents and an increase of the electrical conductivities in the 80–100 km. level caused by β-decay electrons coming along magnetic lines of force from Johnston Island.

The maximum geomagnetic change at Honolulu occurred around the time at which a shock wave from the explosion arrived at Maui, as mentioned below. It is possible, therefore, that there was an additional effect increasing the intensity of the electric currents just at the moment when the shock wave hit. This could have been caused by a dynamo effect resulting from the shock wave.

At the Maui Ionospheric Station in the Hawaiian Islands a sudden increase of f_{min}. (the minimum frequency of the observed radio echo) was observed at 10 : 50 : 22 ± 7 G.M.T. on August 1 lasting several minutes, and again at 10 : 30 : 37 ± 7 G.M.T. on August 12 for a few minutes. These changes were similar to a solar flare effect. However, since they occurred during local night, they must have resulted from the explosions. Probably they were caused by ionization in the *D*-region by X-rays from the blasts.

On August 1 a peculiar oblique echo began at Maui 13 min. after the explosion and lasted until 11 : 12 G.M.T., when it was completely blanketed by increased ionization in the *D*-region. This phenomenon may have been due to a shock wave caused by the explosion. A no-echo phenomenon, called a 'blackout', began at 11 : 12 : 37 ± 7 G.M.T., about 22 min. after the explosion, and continued until 13 : 20 G.M.T. During this time a faint *F*-echo occasionally appeared. After 13 : 20 G.M.T. the *F*2-layer gradually appeared and recovered to normal.

At Maui, between 10 : 56 G.M.T. and 10 : 59 G.M.T. on August 12, both the height and the critical frequency of the *F*-layer decreased abruptly. At 11 : 03 G.M.T. a stratification appeared in the *F*-layer and showed an unusual sequence of changes. This sequence indicates that an irregular ionization in the *F*-layer, caused by a shock wave from the explosion, was propagated horizontally over Maui from the direction of Johnston Island. The estimated speed of the shock wave is about 0·9 km./s. for this event, and 1·3 km./s. for the event on August 1. The wave motion created repeated irregular ionizations in the *F*-layer until a blanketing occurred. A blackout occurred at 16 : 00 G.M.T., 5 hr. 30 min. after the explosion, and lasted 2 hr. Even after that time there was severe absorption until 5 : 00 G.M.T. on August 13. The behaviour of the ionospheric storm of August 12 was in general similar to the ionospheric storm of August 1. On August 12, however, the onset of the blackout was slower and the duration of the radio-wave absorption was much longer, in spite of a smaller geomagnetic effect. The lower explosion height and the daytime onset of the blackout on August 12 may have been responsible for these differences.

Rarotonga also showed explosion effects in the ionosphere for both events. However, other ionospheric stations—Adak, San Francisco, Washington, White Sands, Huancayo, Godley Head and Okinawa—did not show any certain explosion effects. Accordingly, it is concluded that direct-explosion effects on the ionosphere and the geomagnetic field occurred over an area in the central Pacific, roughly the region 170° E.–150° W. and 40° N.–22° S. Radio signals from Honolulu (10 and 15 Mc./s.) and from San Francisco (13·75 Mc./s.) received in Japan showed sudden drops[7] after both explosions. These were due to radio absorption in that central Pacific region.

From the present study of these geomagnetic and ionospheric effects, the explosion height is estimated as 70–80 km. on August 1, and about 40 km. on August 12, although the *New York Times* simply reported it as 100 miles on August 1 and lower than that on August 12.

In addition, three other nuclear explosions that occurred in the south Atlantic on August 27, 30 and September 6, 1958, at about the 480-km. level, were considered. No remarkable geomagnetic and ionospheric effects directly associated with these blasts could be detected in the normal magnetograms or ionograms.

Full details of this work will be published in the *Journal of Geophysical Research*. I wish to express my thanks to Dr. W. O. Roberts and Mr. A. H. Shapley for their kind help, and to Mr. D. B. Bucknam for his considerable assistance. I am also grateful to the Boulder Laboratories of the National Bureau of Standards for an appointment as guest worker and for extending to me their facilities. I wish to thank the International Geophysical Year Data Centers *A* for Geomagnetism and the Ionosphere for the use of data. This study was supported by the National Academy of Sciences as part of the International Geophysical Year Programme with assistance from the Ford Foundation.

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Boulder, Colorado. June 2.

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Magnetic Effects Resulting from Two High-Altitude Nuclear Explosions

On August 1 and 12, 1958, two nuclear devices were exploded in the upper atmosphere above Johnston Island in the North Pacific. No exact information is available to us regarding the heights of the explosions; but it is believed that the first explosion was higher than the second. Unusual magnetic effects, mentioned previously by Cullington[1], were recorded after both explosions on magnetographs at Honolulu, Palmyra Island, Fanning Island, Jarvis Island and Apia. Fig. 1 shows the location of these observatories.

Vector diagrams of the variations in a horizontal plane are shown in Fig. 2*a* and *b*. Fig. 2*a* refers to the first explosion, and Fig. 2*b* to the second. The effects at Palmyra, Fanning and Jarvis are very similar, and only the Jarvis Island diagram is presented here. Variations in a vertical plane are not illustrated, since the only important effect they reveal is a marked downwards movement in *Z* at Apia at about 10:55 G.M.T., following the second explosion.

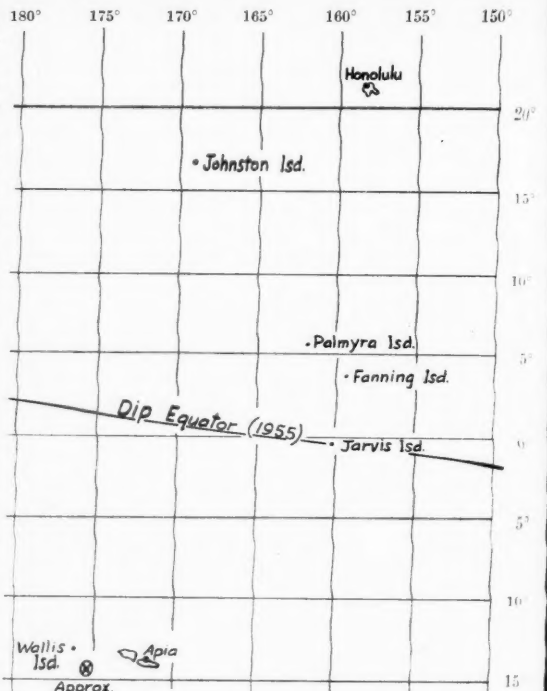

Fig. 1. The region of the Pacific showing islands where unusual magnetic effects were recorded

An examination of these diagrams has led us to classify the effects into four phases—initial, second, main and final, as labelled in Fig. 2*a* and *b*.

We suggest the following broad interpretations.

Initial phase. A hydromagnetic impulse affected by dispersion, corresponding to the Alfvén wave postulated by Kellog *et al.*[2].

The front edge travels faster than 10^8 cm./sec. and the time of the maximum corresponds to the speed of a transverse hydromagnetic wave of frequency 1 c./s. travelling parallel to the magnetic field[3]. Across the lines of force, the impulse travels at about the same speed, but suffers greater damping.

Second phase. Produced basically by the transport of individual β-particles[4], photoelectric and Compton electrons, and possibly ions along the line of force from above the point of the explosion to the conjugate point.

As the shock wave and fireball move upwards, more and more individual charged particles can make their escape. Radioactive decay of escaping high-energy neutrons probably broadens the region over which the transport occurs.

As well as those magnetic fields due directly to the travelling particles, dynamo effects are caused by

(*Continued on page* 51)

BRITISH ASSOCIATION MEETING IN YORK

THE PROPER STUDY OF MANKIND IS MAN*

By SIR JAMES GRAY, C.B.E., F.R.S.
President of the British Association

I

IN the public mind, scientists are largely associated with the study of physical systems and practical problems; they are not directly concerned with moral principles nor are they responsible for the social repercussions of their discoveries. But it is impossible to be a scientist without being a human being and recognizing that social life depends as much on moral principles as on scientific knowledge. So far as science is mainly concerned with our material environment, it tends to isolate itself from the main factors which determine human behaviour. So far as the humanities are mainly concerned with Man's reactions to past environments, we cannot be quite sure how far their judgments are relevant to modern life. Such limitations will not be overcome by keeping our own particular type of knowledge in a water-tight compartment; the sciences and humanities should seek common ground. Hence the title of this address.

During the course of years, the need for a wider social outlook in science has been reflected by two important extensions in the range of the British Association's interests. It now includes the social as well as the natural and mechanical sciences, and it is more and more concerned with the dissemination of scientific knowledge to the whole community. But the wider the field and the larger the audience, the more difficult the task of presentation becomes. Scientists find it more and more difficult to keep abreast of all the main lines of development within their own subject, and almost impossible to know what is happening in other fields; we become more and more specialized and less and less able to see the wood for the trees. It might be said that one of the Association's most important functions is to bridge the gap between its different sections. In addressing the Association, its president has to decide whether he should speak as a specialist and make little or no attempt to relate his theme to wider issues, or whether to stray into unfamiliar fields, and run the risk of scientific, economic or political criticism[1]. Perhaps rashly, I have chosen to face these dangers, by trying to look at man from a biological point of view and to suggest how the picture might—here and there—merge into a wider background. But before doing so, I would like to touch on two quite general topics.

First, one of the most important social aspects of modern science is its repercussion on international relationships. Here there will always be potential danger and waste of human effort until individual nations can be persuaded to think in terms of the welfare of humanity as a whole. A scientific approach to such problems must be one of dispassionate analysis, but we shall not make much impression on public opinion so long as men's minds are biased by fear and suspicion; frightened or angry politicians, like frightened or angry animals, cannot be trusted to react wisely. There is not the slightest doubt, however, that the discoveries of physics *have* frightened mankind and that there are far too many intelligent people looking askance at science and wondering where it is leading them. In trying to link the sciences to the humanities our primary objective should be to depict man's position in the world of Nature as a source, not of fear or doubt, but of courage and inspiration. Our second main objective should be to demonstrate the place of science in a general philosophy of life. To be of real value, such a philosophy must rest on knowledge and experience which have already proved acceptable over a very wide range of local environments and national interests, and it must, at the same time, be closely concerned with problems of everyday life. In these respects science is unique. Except so far as they are subject to political restraint, scientists of all nations co-operate in solving Nature's jig-saw puzzles, and as Prof. A. V. Hill said at Belfast[2], "The fundamental principle of scientific work is 'the unbending integrity of thought, following the evidence of fact wherever it may lead within the limits of experimental error and honest mistake". This attitude of mind is not peculiar to scientists; it is common to all who have a respect for the truth. But in the fields of law, language, history, literature and, above all, politics, our general outlook and our individual range of knowledge depend to a very dangerous extent on local environment and national tradition. By freedom from such limitations science provides ground—perhaps the most solid ground—on which to base a wider range of co-operative effort. But the gap between a scientific and a humanitarian outlook cannot be bridged by the statistical laws of physics and chemistry; we are forced to apply the less precise, but not necessarily less important, principles to be derived from the world of living organisms. The challenge is, therefore, to the biological sciences, especially those which deal, at the borderline of sociology, with the behaviour of organisms and their relationship to their environment. Can they yield broad principles which are applicable to man, or must scientists be content to see the law of the jungle take its course except in so far as it can be restrained by humanitarian effort? The answers to such questions may well decide how far science can claim to be of direct cultural significance.

* Presidential address delivered in York on September 2 and appearing in the September issue of *The Advancement of Science*.

II

Man's position in the world of Nature is brought most sharply into focus by the concept of natural evolution. Cosmic, biological and human evolution can be regarded as phases in a continuous natural process—and, from this point of view, astronomy, geology, biology, archæology and history form a continuous spectrum of knowledge. To pass from a primeval nebula to a modern man without any sudden break in continuity of thought gives a feeling of intellectual tidiness, but quite apart from this it helps us to visualize man against the background of his past and to regard him as Nature's supreme masterpiece. At the same time, he must not get *too* big for his biological boots or tend to exaggerate the gap between himself and the rest of the animal kingdom. No animal can manufacture aeroplanes, Asdic or radar; but the prize for aeronautics must go to the shearwater which navigated the Atlantic without compass or chart, while Asdic has an extremely efficient prototype in the vocal cords and ears of bats. By surrounding themselves with an electric field, some fish (for example, *Gymnarchus*) can—in total darkness—detect foreign objects in the surrounding water with very remarkable precision. The weight of the mechanism involved—including the animal's brain—amounts only to a few grams; a man-made instrument of comparable performance would involve at least a ton of highly complex electronic machinery. In fact, as delicate and precise pieces of machinery, man's inventions have not yet reached the standards of those produced during the natural course of biological evolution. No laboratory in the world can compete with the biochemical skill of even the smallest living organism. On the other hand, man can claim that within a few centuries he has produced things for which Nature required many millions of years; but we need not feel in the least ashamed of the older members of our evolutionary family: we have still a great deal to learn from them.

To visualize man's position in the animal world, it may be useful to define his main diagnostic characters. He is a highly gregarious bipedal mammal with unspecialized limbs but a very large brain. He is the only animal which has developed the symbolisms of speech and writing and he may well be the only animal capable of rational thought. He is, therefore, the only organism which can hand on patterns of acquired learning from one generation to another. To these advantages he owes his dominant position in the world to-day. They have enabled him to exploit his environment and increase his numbers and range of distribution far more quickly and far more extensively than any animal of comparable size. He has eliminated some of his competitors and exploited others for his own use, but the time has now come when different races of men are competing with each other within the closed arena of a limited environment, and it is not easy to see where it will end. There is nothing equivalent to this in the inanimate world; but, when a biologist looks at the general trend of events, he is inclined to say, "Where have I seen something like this before, what is it due to, and how does it *usually* end?"

Of the many points of view from which biologists can study man, three are of particular social interest. First, what is the relationship between the size of a human population and the resources of its environment? Secondly, what are the factors which influence man's ability to acquire new patterns of behaviour? Thirdly, what is the significance of the gregarious habit?

One of the first attempts to subject social problems to biological analysis was made by Malthus in 1789 when he forecast the fate of a nation the rate of increase of which was greater than that of the resources of its environment. Malthus did not say that war, pestilence and famine were inevitable; he said that they were inevitable unless people, by voluntary control, reduced their rate of reproduction. The theory of animal evolution by natural selection, enunciated just a hundred years ago by Darwin and Wallace, involves the principle of over-population and introduces the concept of randomly produced mutations. Some of these increase an individual's chance of survival whereas others decrease it: those which best adapt the animal to the conditions of life imposed by the environment survive, the rest are eliminated. The course of animal evolution is not directed by the organism itself, but by the external environment; the animal throws the dice but the environment decides the winning numbers. A persistent struggle within an over-populated environment is an essential condition for evolution by means of natural selection; it is the price which Nature demands for progress. There is no evidence that adaptations acquired during the life-time of an individual animal can be handed on to its offspring; each generation has to take an environment as it finds it and make its own way in the world. There is also the danger of over-specialization; a species which has become very highly adapted to a particular environment may be extremely vulnerable if the environment changes relatively suddenly. The course of human evolution is entirely different. Speech and writing enable each generation to modify and control its environment in the light of experience gained by its predecessors and to hand on acquired benefits without bodily specialization. As soon as man learns to discipline himself to the fact that his environment is world-wide, he can begin to direct the course of his own evolution without the discomforts of over-population. If he fails to realize his powers and allows things to drift, his future seems dark; if he really bestirs himself, there is much less need to be afraid.

Quite apart from any evolutionary significance, there can be no doubt about the validity of Malthus' argument. Western Europe and North America have followed his advice; but, as stressed by Prof. P. M. S. Blackett[3], the density of population in other parts of the world is far higher than can be adequately sustained by the environment. We can, of course, shrug our biological shoulders and say that different races of men live in different environments and are, therefore, subjected to different intensities of struggle, and it would be comforting if we could be quite certain that it is always the fittest which survive. We cannot salve our consciences quite so easily nor will *we* escape for very long from environmental pressure. Our own population may remain relatively stable, but our environment expands with almost every new major scientific discovery, and the greater the overlap of the environments of different nations the fiercer is the competition. The result is substantially the same as that of an expanding animal population within a limited environment. These problems lie within the field of Section *F* (Economics), but they are fundamentally similar to those which arise in animal ecology; it seems just as unrealistic to regard

one race of man as an isolated unit as to study the population of one member of a biological food-chain without reference to those of all the others. The writing on the wall is tolerably clear ; if man behaves like an animal and allows his population to increase while each nation steadily increases the complexity and range of its environment, Nature will take her course and the law of the jungle prevail.

To see this law in action, it is useful to remember that Nature has made, not one but two, great experiments in the design of social animals. The first was carried out in Mesozoic times when man's mammalian ancestors were beginning to emerge from reptiles. The results of this experiment are represented to-day by the social insects—notably the ants. There are a very large number of different species of ants none of which interbreed ; among them is found a range of complexity of social behaviour which is not only unique in the animal kingdom but which also forms a very remarkable parallel to different races of human beings. At one extreme are species forming small communities, restricted to localized or specialized environments and exhibiting relatively little sub-division of labour between individuals. At the other extreme are large and often aggressive communities with marked differentiation of structure between different grades of individuals ; populations of this type display high levels of co-operative effort involving, in some cases, the rudiments of agriculture and husbandry. In all cases, however, ant societies are organized on a straightforward totalitarian basis, for the contribution made by each individual towards the welfare of the community is determined from the time of birth ; each grade of individual is structurally adapted for predetermined tasks. How far ants can communicate with each other may be doubtful, but it is tolerably certain that members of the same community recognize each other by a characteristic smell, and as the brain of an ant is about the size of the head of a pin, it is perhaps not surprising that ants should attack or kill an individual from another colony with a smell slightly different to their own. It is much less easy to understand why a man, with a brain of an entirely different order of complexity should, at times, react almost equally violently to skin pigments slightly different to his own.

But it is not only in respect to individual relationships that the study of ants is relevant to man. Ants are the only organisms which—apart from man—indulge in organized warfare, raiding the nests of other species and incorporating captives into their own society. But perhaps the most striking facts relate to species which have changed their habits and distribution within recent times. Two instances of territorial expansion are known to have occurred in the past 150 years[4]. Early in the nineteenth century an Eastern species (*Pheidole megacephala*), having spread rapidly over North Africa and South Europe, managed to reach the islands of Madeira and Bermuda ; in both places it exterminated the smaller native races. Meanwhile, a similar policy had been carried out by another species (*Iridomyrmex humilis*) from the Argentine which, having landed at New Orleans, very rapidly overran the southern United States ; in due course it too reached Bermuda, where it proceeded to eliminate *Pheidole*. In the world of ants there is no place for small peaceful communities unless they can isolate themselves effectively from larger and more powerful neighbours, nor does there seem any lasting peace between large aggressive communities. Solomon's advice has, I suspect, been misinterpreted. It should read : "Consider the ants, and, if you use your intelligence, you will see how *not* to deal with international problems".

Having designed the ants, Nature waited for about 150 million years before embarking on her second or human experiment. She waited, in fact, until it could be carried out with a species in which an individual's contribution to society was no longer based on inherited structural characters but on the power of intercommunication with other individuals ; in other words, until man's brain had reached a level of development which enabled him to control his environment, and to deal rationally with the sub-division of labour between individuals and with the distribution of natural resources between different groups of individuals. At the same time she arranged that such groups should not be physiologically isolated from each other. Different races of men can interbreed or they can, if they wish, come to mutual agreement about the distribution of world resources between different nations. The first policy would seem to lead to a World State with uniformity of social pattern and of material interests ; the second policy involves territorial limitations and economic agreements. Both, as we know only too well, involve great practical difficulties. All the same, men really ought to be able to do something better than ants.

The second basis of comparison between man and animals concerns the factors which control his behaviour. The past fifty years have produced a very great increase in our knowledge of animal behaviour and about the factors which control the acquisition of new patterns of response. For present purposes, however, attention may be focused on two problems ; the extent to which animals can profit from extraneous instruction, and the extent to which they are able to learn for themselves. The first of these fields is explored by means of the conditioned reflex technique, whereby an animal learns to associate a specific visual, or other sensory, stimulus with forthcoming food or impending danger. In order to establish this result it is necessary to conform with five basic principles, all of which have their counterpart in the training of human beings :

(i) The response expected from the animal must not be unduly complex ; the animal must be able to reach the food or escape the danger by making reasonably simple movements. In other words, the problem must not be too difficult. (ii) The lesson must be presented to the animal under conditions which ensure freedom from extraneous disturbance. It will not learn if its attention is constantly diverted by other changes in its environment. (iii) The problem must be presented to the animal on an adequate number of occasions ; the more frequent the lesson, the fewer the mistakes become. (iv) There must be an 'incentive' to learn—a 'reward' for success or a punishment for failure. Further, the 'reward' must be related to the needs of the animal. (v) Finally, the experimenter must possess adequate skill and patience. The ability of an animal to learn depends to a very large extent on the personality and enthusiasm of the teacher.

These five principles apply equally well to the education of human beings if we make suitable allowances for increase in complexity of the lesson to be learned and in the nature of the incentive to learn. But we can go a little further for, as with men, different individuals of the same animal species learn at very different rates. On the other hand,

there does not seem to be any clear correlation between an animal's ability to learn and its position on the evolutionary tree. It is possible to trace the structural evolution of the human brain through each of the main classes of vertebrate animals; the large paired hemispheres arose in the Devonian lung-fishes and the cerebral cortex in the early Permian reptiles. It would be very convenient if step by step with an increase in size and complexity of the brain it were possible to trace a corresponding increase in complexity of behaviour and in ability to learn. Unfortunately this is not the case; some fish, without hemispheres or cortex, exhibit behaviour patterns which seem just as complex as those of reptiles or even of some mammals. In due course this difficulty will be resolved but for the time being one can only say that there seems to be one feature common to all species which learn easily, namely, a vivacious but not unduly excitable temperament—fish, rats, monkeys and children are all interested in their surroundings, they have a natural tendency to explore their environment and they are interested in anything new or strange; they are all, perhaps, potentially good scientific observers.

But the value of the instruction given to human beings by a teacher is largely judged by the extent to which it enables a pupil to make use of his acquired knowledge and to go on to learn more by himself. Within the animal world there is very little evidence to suggest that experience acquired from one pattern of environment or from one problem can be readily applied to subsequent ones of somewhat different nature. An animal's own approach to a problem, like that of a very young child, is very largely one of random exploration; having found the solution by chance the number of ineffective responses on future occasions becomes less and less until the correct response is stabilized.

How far animals display evidence of the higher levels of mental analysis associated with 'intelligence' in human beings is not too clear, for it is extremely difficult to subject intelligence to an agreed standard of measurement. When judged by human standards, the I.Q.'s of all animals are, undoubtedly, very low; but it may be that we are not always setting *them* quite the right type of examination.

Although it is difficult to detect an increasing capacity to learn with an increase in size and complexity of the brain throughout the main classes of vertebrates, it seems clear that there is a substantial increase in learning ability as soon as an animal's brain reaches a level of structural complexity comparable with that of man. The young chimpanzee, like a human baby, is typically a friendly playful creature dependent on, and with an affection for, its mother. But as it grows up, it begins to show marked signs of individuality; some become morose, unfriendly and vicious, others retain a friendly disposition towards their neighbours and a co-operative attitude towards human teachers. The ability to respond to training shown by the latter type of individual is, of course, very remarkable; but when left to itself, a chimpanzee seems to rely on an initial process of trial and error. Like many other mammals, it can give audible and visible signs of fear, anger or pain; but there is no evidence that a chimpanzee can make audible or visible signs which other individuals associate with specific material objects; the mental development of the adult ape seems roughly equivalent to that of a human baby before the latter has learnt to speak. Nothing can disguise the enormous difference between an adult ape and an adult man in ability to learn and to control their environments, but it might be argued that a relative test of the brains of an adult ape and of an adult man, as computing instruments, should be conducted on the basis that neither pupil nor teacher should be allowed to speak, read or write; the gap between animals and men might narrow very appreciably.

The third and perhaps most important biological aspect of man's behaviour concerns the gregarious habit. Here again the distribution among vertebrate animals is curiously unrelated to their evolutionary history; it is well marked in certain species of fish, birds and mammals, but absent in others. In some cases the existence of a herd or flock is clearly of survival value; a pack of wolves has a wider choice of food than an individual operating by itself. But, it is not always clear why one species should be more gregarious than another to which it is closely related. In the present state of knowledge, it may be safer to say that some animals are restless or uneasy unless in close proximity to individuals of the same species—that they have, in fact, a deep-rooted antipathy to isolation or loneliness. The resultant grouping establishes the herd as a unit which responds as a whole to an external stimulus applied to one or a few individuals. The response is most clearly defined when the stimulus evokes an emotional reaction of fear or anger in the individuals directly concerned, and one of the most distinctive features of herd behaviour is the speed at which these emotions spread throughout the community. If certain individuals are more highly susceptible than others to external stimuli, the response of the group is determined by the most timorous or the most belligerent members of the community. The majority of the herd subjugate their own individual behaviour to that of a few, and in the long run individuals benefit by greater security from predators or greater certainty of obtaining food. If an individual is unduly insensitive to emotional stimulation by its neighbours, it is likely to be eliminated by natural selection—the sheep that walks by itself gets eaten and the solitary wolf may starve. These principles were applied to the analysis of human behaviour by Wilfrid Trotter[5]. In order to avoid physical or mental isolation, men are prepared to subjugate their own immediate needs or predilections to those of society as a whole. Anti-social activity is kept in check by fear of intellectual or physical isolation; feelings of increased security and greater freedom from personal doubts and fears are set off against loss of individual freedom of action. How far psychologists have developed or rejected Trotter's suggestions I do not know, but there can be little doubt that they opened up a useful biological approach to sociology by suggesting that our instinctive reaction to something new or strange is, as in animals, to conform with our neighbours, and that, at moments of crisis, it is better to follow a leader than rely on personal judgments. These and allied problems belong to Section *J* (Psychology). All I wish to stress is that the phenomena of mass psychology in man, like other aspects of his behaviour, have their roots far down in his evolutionary history.

Perhaps the most striking difference between the social habits of man and those of animals is the existence of a hierarchy or grading within human society. Only in a very few cases does this appear to exist within the animal kingdom. The nearest

approach seems to occur in birds ; a flock of jackdaws feeding in a restricted area resolves itself into a well-marked order of feeding priority. Lorentz has recently reported that if a high-ranking male decides to mate with a low-ranking female, the latter rises in social status and feeds with her husband ; all this sounds reasonably familiar to human ears.

This is perhaps as far as a zoologist ought to go in trying to view mankind through biological spectacles. But one does not need to be a professional biologist to appreciate that the rates of change in the pattern of human behaviour and in the nature of our environment have, during the past five thousand years, been incomparably greater than those of any other organism at any period of its history ; our clothes, houses, habits and social organization change with successive generations. In fact, if one were forced to select the organism which best displays the phenomenon of persistent evolution one would undoubtedly choose man. I have tried to show that the broad principles which relate the size of human populations to the resources of their environments and those which govern an individual's ability to learn from personal experience and so adapt himself to his environment are qualitatively similar to those which apply to animals. On the other hand, man is—as I have said—unique in that he is—or can be—the master and not the slave of his environment, and the story of his later evolution is told in terms of social and economic history.

In suggesting further points at which biological principles seem to be applicable to the evolution of human society a zoologist can only look towards Section *H* (Archæology and Anthropology) and hope that his spectacles are not completely out of focus. In its very early stages human society must have been organized into quite small units each dependent on the natural resources of a small circumscribed environment. The discovery of fire and development of agriculture must have increased the range of the environment and the optimum size of the population required for its exploitation, while the stability of the group would become more and more dependent on the maintenance of an effective sub-division of labour. The larger the population and the greater the degree of specialization the greater the limitations necessarily imposed on individual freedom of action. A new and very important integrating factor seems to have come into action when natural phenomena became linked with supernatural concepts—fear of isolation or reprisals from fellow-men being reinforced by fear of a superhuman agency and a sense of greater security inspired by reliance on supernatural support. Such beliefs had no material basis but they would be the cement which held society together and, as such, be of immense survival value. But it is difficult to avoid the conclusion that such beliefs, like scientific theories, must undergo change as man's knowledge increases and his environment alters. From this point of view, it is not easy to regard any one belief as an expression of absolute and unchanging truth. It may be argued that such things lie outside the orbit of the British Association ; but if science is to be of direct cultural significance, it cannot shut itself off from one of the main factors which have influenced men's attitude to social problems. A recent issue of *Nature*[6] contained a leading article on the proceedings of the last Lambeth Conference ; it must have been a very long time since an Archbishop of York addressed such a Conference in language which scientists could so readily understand. Against such a background, the sciences and the humanities ought to be able to find something in common.

III

It is easy to say that science should be welded to the humanities, but much less easy to suggest how this should be done. Each of us has different views according to his own particular interests. I confess that my own approach is based on personal experience. About fifty years ago I chose to specialize in biology, and from time to time I have been asked, "If you had known that you would spend a good deal of your later life studying the movements of animals, what subject apart from biology would you have read at school and at the University ?" The answer is simple : I would have read physics, chemistry, mathematics and mechanical engineering. The moral is that no young scientist should be allowed to forget that new discoveries tend to arise from the borderland between different subjects where the discipline of one is applied to another. Had I appreciated this I would have been a much better biologist ; but whether I would have been a better human being is another matter. If I am asked the 64-thousand dollar question, "Had you known that you would have had to adjust yourself to a rapidly changing and somewhat uneasy world, what additional training would you like to have had ?" I think my answer would be that I would like to have been trained to think dispassionately about social and political affairs in the light of experience drawn from the past, and to have been taught to appreciate beautiful things. But could I have acquired this knowledge while training as a scientist ? Perhaps not, but I still think that I could have been shown a wider picture. Having been taught to visualize the spectrum in terms of the wave-lengths of light, could not I have been encouraged to learn a little about colour as a source of æsthetic pleasure ? Why did I learn about the properties of iron and carbon without reference to the industrial revolution ? I might even have developed a taste for the classics if I had known that Aristotle had written a very good text-book of zoology. Perhaps I expected too much in hoping to appreciate an artist's view of Nature from the point of view of the scientist. But I am not completely convinced. A scientist's attitude towards his observations does not seem to me to be so very different from that of a poet towards his words or a painter towards his colours ; isolated observations have no more value than single words ; it is only when they fit into a satisfying pattern that the scientist feels he has achieved his end. This analogy may be unconvincing, and if it still seems difficult to combine the vision of the artist with the outlook of a scientist, I can only suggest that Leonardo da Vinci and Sir Christopher Wren seem to have had pretty good shots at it. It would be very interesting to know the sort of training they had in early life.

But a plea for a wider outlook in the teaching of science is nothing new. It was largely the background against which Section *L* (Education) came into being, and it was urged again and again by Sir Richard Gregory. Since then there has been much discussion and many reports. In 1933 the declared aim of the London County Council was that they "wished their pupils to obtain a broad view of nature, to study Mankind and his environment from various standpoints, more particularly from the point of view of both the biological and physical Sciences". In 1946, the Advisory Council for

Secondary Education in Scotland was even more explicit: "During the earlier secondary years at least, the study of man in his world, like the study of science, is a unity which should not be broken by any sharp division into 'subjects' . . . the theme must be one". Only last year (1958) a Committee of the Science Masters' Association urged that "The schools have the duty of presenting Science as part of our common cultural and humanistic heritage; it should be taught in harmony with and not in opposition to the various Arts subjects. . . ." It seems fair to assume that this is a goal towards which we would all wish to strive; but when we try to approach it the road proves extremely hard and most of us, in practice, fall by the wayside.

We cannot shut our eyes to the fact that our national economy depends on our ability to make and exploit new scientific discoveries. If we wish to maintain or extend our standards of material comfort, we must have more professional scientists and highly trained technicians, and we must be prepared to devote an adequate fraction of our educational effort to get them. But highly trained specialists form only a very small proportion of the population, and we may be paying for them in very hard currency if we have to deny to a very much larger fraction of the community a reasonable chance of "seeing life steadily and as a whole". A democratic society has to decide how much of its total educational effort should be devoted to an ever-increasing standard of living, and how much to raising the intellectual standards whereby the majority of the population forms its judgments on matters which are susceptible to personal prejudice or political propaganda. It is not easy to assess the factors which mould public opinion, but a recent inquiry sponsored by the Nuffield Foundation[7] and the B.B.C. indicates relatively clearly that the attitude of mind of an individual towards a changing environment is directly related to the nature and extent of his full-time education and that it is this training which largely determines, in later life, his response to other potential sources of education—such as libraries and broadcasts. If we wish to awaken a widespread interest in science, or—still more—wish to contribute toward the formation of an enlightened public opinion, we must sow our seeds in the schools and in organized centres of adult education. In the latter field, the Area Organizations of the British Association are of fundamental importance as authoritative and coherent sources of information for an increasing fraction of the community. By working with other organizations they can make a very definite impact not only on the scientific but also on all aspects of public opinion.

But the key to the main problem lies in the schools, and the responsibility resting on school teachers can scarcely be exaggerated[8]. Too many are asked to do two jobs at once—to provide a training for potential specialists, and at the same time give a training which will best equip the average boy or girl for later life. If we are to pay more than lip service to the belief that a good all-round education is the best means of raising the intellectual level of the community, we must recognize that our most urgent need is for good general practitioners in the art of education. Really inspired teachers working with adequate but simple equipment will achieve more for general education than specialists in highly equipped laboratories. But the scales have been heavily weighted in favour of specialization. Almost exclusively, our universities are producing specialists. Some of these return to the schools, where they in turn teach on a specialized front. So the spiral of specialization has gone on. It is only natural that able teachers should get an intellectual stimulus by preparing boys and girls for scholarship examinations and so providing recruits for fields of research in which they themselves are interested; but it is by no means clear that their work is necessarily more important, or more difficult, than that of those whose primary object is to persuade people that they cannot live by bread alone. If we really believe in general education, we must produce and encourage the right type of teacher. No man or woman in their senses enters the school-teaching profession for financial gain, but a community which rates thirty inspired school-teachers as equivalent to one high-grade comedian or film star may well deserve a very unhappy fate. A benevolent dictator would make school-teaching the most highly respected and the most highly paid of all professions, and the Ministers of Education the most important officers of government; but, in both cases, he would demand a very high level of performance. We must do the best we can without him.

The value of an educational system can perhaps be judged by the extent to which it leaves people with a desire to know more about the world at large and a feeling that this can be satisfied, at least in part, by personal effort. To meet a constantly changing environment the general pattern of teaching must be constantly under review. If a curriculum is allowed to degenerate into a series of isolated subjects with little or no immediate bearing on everyday life, the result can, perhaps, best be described in words which I think the president of Section *L* (Education) will recognize: "When far too many boys and girls will carry away from school little more than gobbets of ill-digested knowledge and a distaste for what has yielded so little"[9].

But, as I have said, it is easy to talk and to criticize, it is much harder to plan for action. So far as science is concerned, the British Association might approach the problem of general education in the three familiar stages of research, development and production. The first step would involve an assessment of the evidence: if the Association's judgment were given in favour of a wider, and perhaps more biological, outlook on education, it should do all it can to see that it is put into practice on a limited front and—in the light of experience—allowed to spread gradually into full-scale production. All this would involve very far-reaching reorganization of schools and universities. While Oxford and Cambridge shiver on the brink of optional Latin, the University College of North Staffordshire is swimming the Hellespont by insisting that all students should, during their first year, survey the whole field of knowledge as a coherent picture before proceeding in three subsequent years to specialized training. This is, in my opinion, one of the most important and courageous educational experiments in our times for, if it succeeds, a great number of our major difficulties will be resolved.

On the other hand, if 'general education' and 'general science' are condemned as 'smatterings of everything and a knowledge of nothing', and if the concept of a central theme around which all parts of a syllabus would revolve be found to be illusory, it is high time we stopped talking about the broad cultural value of science and concentrated our efforts on widening the interests of specialists during or

after their technical training. Much can be done by relatively formal teaching, but—if I may judge from personal experience—more depends on the extent to which students are given the time and opportunity to educate themselves by contact with men and women with entirely different interests and outlook from themselves. This is the great strength of the older residential universities; but, here again, they may have something to learn from North Staffordshire.

But the older we get the less inclined we are to go back to school. If we want every member of the population to keep in touch with what is going on in the scientific world and to realize its impact on their lives, we must rely on the Press and on the broadcasting authorities. Neither of these is primarily an educational medium; in both cases the main objective is to put science across in a form that readers and listeners find interesting. In respect to music, the B.B.C. has been outstandingly successful; other fields of broadcasting may be less amenable, and it is not altogether easy to know how far an increase in factual knowledge concerning a number of isolated fields of science enables listeners to appreciate the broad social and international implications of science as a whole.

But when all is said and done, science can only play its full part in furthering the welfare of mankind if it is used at a very early stage of education, as a means of encouraging a dispassionate but optimistic attitude towards all aspects of human affairs. To move from national traditions and aspirations to others based on international welfare may prove less painful if we are prepared to look on man and all his problems as a phase in the evolution of the universe, and if we have the courage to believe and to teach that he can, by means of his intellect, control and direct his own evolution and destiny.

[1] See Blackett, P. M. S., *Advancement of Science*, **15**, 367 (1959).
[2] Presidential address to the British Association (1952).
[3] Presidential address to the British Association (Dublin, 1957).
[4] Haskins, C. P., "Of Ants and Men" (1945).
[5] "The Herd Instinct in Peace and War".
[6] *Nature*, **182**, 965 (1958).
[7] Thirteenth Report of the Nuffield Foundation, 66 (1958).
[8] Proc. B.A. Conference "Science in Schools" (1958).
[9] Report of the Advisory Council for Secondary Education in Scotland, 25 (1946).

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

THE VISUALIZATION OF MAGNETIC PROCESSES

IN delivering the presidential address to Section *A* (Mathematics and Physics), Prof. L. F. Bates prefaces his remarks with a brief outline of the ferromagnetic domain concept. He then describes the several ways in which the boundaries and surfaces of such domains in single crystal and in polycrystalline materials may be manifested. He shows how the original Bitter figure technique has given results of great value concerning main domain and closure domain configurations; it has provided considerable support for the ideas of Néel and others as applied to the magnetization processes which occur when single crystal specimens of appropriate shape are exposed to magnetizing fields, and has given visual proof of the important effects of inclusions, defects and strains on magnetization phenomena.

The technique has recently been much extended first by Craik's development of a detachable colloid film carrying with it a record of domain configuration, which can be examined optically and also in a commercial form of electron microscope. Craik and Griffiths have shown that the film technique can be successfully used to examine fine domain structures on ferrite surfaces prepared by the simple cleavage of single crystal specimens. By using films of ever-decreasing colloid concentration, Craik found the minimum thickness of a continuous deposit above a 180°-domain wall on a cobalt crystal to be 10^{-5} cm.

The colloid film techniques restrict the experiments to static observation and to limited ranges of temperature, and recently attempts have been made to develop dynamic methods. Perhaps the most successful is the polarized-light technique of Lee, Callaby and Lynch, which has been applied to the motion of a domain wall in a thin sheet of polycrystalline 'Perminvar', an alloy of approximate constitution $Ni_{45}Fe_{30}Co_{25}$, which has been magnetically annealed by cooling it in a magnetic field. Davis has followed the motion of such a wall by pick-up in a search coil wound on the specimen. Lee, Callaby and Lynch have used the transverse Kerr effect. The specimen is illuminated by a beam of plane polarized light, which forms a small strip on the specimen surface, roughly parallel to the wall, and which acts as a light probe. The reflected light is collected by a microscope, passes through a 'Polaroid' and is thrown upon the cathode of a photomultiplier. As a domain wall moves across the beam, the intensity of the collected light changes, the change being made periodic by the application of a weak alternating field to the specimen. The current from the photomultiplier is amplified and a signal displayed on a cathode-ray oscillograph. By using two light probes a domain wall can be made to move through each in turn, so that the velocity of wall movement can be followed. It is found that the velocity is fixed almost entirely by the eddy currents in the specimen.

An electron microscope has been directly applied by M. Blackman and others to examine the stray fields at the edges of ferromagnetic specimens, and in this way it has been shown that the domains in hematite are unexpectedly large. Spivak and his collaborators in Moscow have obtained direct photographs using the secondary electrons released by a primary beam on the specimen surface. They have also used an electron mirror method. Kaćzer, in Prague, has used a thin 'Permalloy' probe vibrating above the surface of a specimen to map domains. However, all these methods have to date been less informative than the colloid method, and may more readily manifest surface imperfections and inhomogeneities than domain walls, but they may, of course, be greatly improved in future.

MEDICAL ASPECTS OF COMPLEX CARBOHYDRATES

PROF. M. STACEY points out in his presidential address to Section *B* (Chemistry) that carbohydrates play an essential part in the vital processes of all living cells. Their simplest forms, the monosaccharides, are synthesized from carbon dioxide and water in the leaves of living plants by the agency of sunlight and chlorophyll. The chemistry of these photosynthetic processes, including sugar interconversions, phosphate transfer and the enzymes involved therein, is now being worked out. Likewise, the mechanisms of the build-up and breakdown of the complex carbohydrates, the polysaccharides, is now well established.

Microbial and animal cells, devoid of photosynthetic pigments, must use the simple sugars as material and energy sources for their own metabolic cycles. The proper carrying out of these cycles is necessary for the healthy condition of every living cell, and in the animal the blood sugar (glucose) balance must always be maintained. For the growth and reproduction of cells and tissue, complex polysaccharides must be built up, for example, to form cell membranes, structure and storage material and colloidal fluids, while the pentose sugars form a part of the genes and chromosomes.

Some of the important processes in which both simple and complex carbohydrates are involved are discussed by Prof. Stacey.

(*a*) *General metabolic processes.* These involve digestion of foods and the absorption of glucose and other sugars; they involve the metabolic cycles and the function of enzymes concerned with them. They concern the synthesis and breakdown of glycogen, the conversion of sugar to fat, the biochemistry of muscle action, formation of milk, etc. The hormones insulin and epinephrine are involved in glycolysis. The great medical value of insulin in controlling diabetic conditions is well known. In this field synthetic substitutes for use in diabetes are being actively studied.

(*b*) *Detoxication mechanisms.* Frequently the body needs to get rid of excess toxic substances such as drugs, and it can do this by oxidation processes, coupling up with the sugar acid D-glucuronic acid and then excreting the complex. D-Glucuronic acid is an important tissue component.

(*c*) *Structural components of the body.* It is with these substances that we can expect to see great advances in the future, for complex carbohydrates known as mucoproteins and mucopolysaccharides form a large part of components such as bone and cartilage tissue, cell membranes, connective tissue, skin and its ground substance, joint fluids, synovial fluid, eye tissues and fluids, gastric and intestinal mucosa, etc.

These complex polysaccharides have as their building units nitrogen-containing or 'amino'-sugars, hexuronic acids and hexoses, and often, too, acetyl and sulphate residues are present. Associated with the carbohydrate protein complexes is a novel group of 'nine-carbon' sugars, the nonulosaminic acids, known as sialic and neuraminic acids. Detailed work on the chemistry and biological importance of these acids is not yet well advanced. Generally, the mucopolysaccharides are concerned with movement of parts of the animal body and thus are important in conditions of arthritis, rheumatism, etc., and with general ageing processes.

(*d*) *Blood components.* Many components of blood contain complex carbohydrates; the red cell surface contains mucoproteins, white cells contain nucleic acids, while serum contains a wide range of mucosubstances.

Furthermore, many tissues and fluids of the body such as gastric mucosa, saliva, etc., contain the so-called blood-group factors, which are polysaccharide–amino-acid complexes. One of the most important medical developments has been with blood plasma substitutes, where the bacterial polysaccharide dextran has become established as an excellent expander of blood volume. The clotting of blood in the body is inhibited by heparin, a complex polysaccharide sulphate, the action of which can be imitated by other polysaccharide sulphates.

(*e*) In many other directions carbohydrates are becoming of increasing importance. In the antibiotic field, streptomycin is an important complex carbohydrate, while many others such as puromycin, magnamycin and kanamycin contain amino-sugars.

In disease-producing agents, the complex surface carbohydrates play a significant part in immunity studies, and there is a close relationship between carbohydrate structure and immunological specificity. Pyrogens or fever-producing agents from bacteria are also carbohydrates. Muco-substances and the enzymes which destroy them are important in fertilization processes, but little is known at present about the carbohydrates of eggs.

A new branch of carbohydrate chemistry is developing in the virus field, and the necrosis of some tumours by bacterial polysaccharides has yet to be studied in detail.

RECENT DEVELOPMENTS AND TRENDS IN PALÆONTOLOGY

THE past two or three decades have witnessed a remarkable increase in the output of palæontological research. Most of this has been of a purely descriptive character, often related to the needs of the stratigraphical palæontologist, but much has been of more general interest, particularly in the borderline fields of taxonomy and evolutionary theory. Prof. O. M. B. Bulman attempts in his presidential address to Section *C* (Geology) to give a non-technical account of palæontological activities in some of these directions.

Chance plays a large part in the preservation and discovery of fossils, and modes of preservation limit the techniques which can be applied. Hence from the nature of his material, the palæontologist has less freedom than the neontologist in planning his research, and is often unable to follow some otherwise desirable line of investigation. New material is, however, constantly being obtained, and the scale on which effective techniques are being devised and applied is a distinctive feature of modern palæontology. Particularly characteristic of the immediately post-war years also have been the many attempts at constructive syntheses of palæontology and allied sciences.

Palæontology provides a general and imperfect, though steadily improving, record of most groups of organisms, and in supplying a few true evolutionary series it has given a fourth dimension to the concept of the species. Applying the results of absolute rather than merely relative dating of rocks, it is

beginning to contribute some tentative calculations of evolutionary rates in various groups, particularly among vertebrate animals; and the establishment wherever possible of invertebrate phylogenies will have rewarding results here as in other fields. The problem of evolutionary mechanism is a purely zoological one, but the ultimate proof or disproof of evolutionary theories involving phylogeny, such as proterogenesis, recapitulation and orthogenesis, also lies fairly within the field of palæontology.

The major contributions in palæontology have been made where its limitations have been frankly recognized and its unique assets most fully exploited. These are, of course, the time factor and the historical record of evolution. To bring palæontological evidence into the evolutionary picture, however, involves a synthesis with genetics, taxonomy and zoology from which is now emerging a new 'science of four-dimensional biology'. In such studies, the emphasis has tended to shift from the individual to the population, with the consequent need for statistical treatment, and successful generalizations will call for accurate quantitative as well as qualitative methods of research; but Prof. Bulman emphasizes in this address the primary importance of the most detailed and exact morphological investigations which contemporary techniques can provide.

MAN AND THE WORLD'S FAUNA

DR. L. HARRISON MATTHEWS, in his presidential address to Section *D* (Zoology), points out that man has continually preyed on the fauna of the world. The increase in the human population and man's technical skills have enabled him to exploit the fauna with ever-increasing destructiveness. It was not until the populations of animals were reduced below the danger point that man realized that they were not inexhaustible. Destruction of particular species has also been due to man's destruction of the environments to which the fauna has been adapted. Human settlement of land and the development of agriculture have caused many animals to be banished from their natural environments.

Man now realizes that breeding fauna in captivity will not alone maintain its existence. He has introduced legislation prohibiting or limiting the killing of certain species and has provided sanctuaries in the form of reserves. It is essential, however, that the conservation be not only applied to the fauna but also to the environments. Basically, it is a problem of land management and development, vital to man as a means of producing energy—food and other useful products.

For the conservation of animals specifically for commercial purposes, Dr. Harrison Matthews gives examples of the recoveries for the fur-seal and the elephant-seal, and how extinction in the Antarctic was prevented by the intervention of the Falkland Islands Government. He also mentions the not so satisfactory history of the whaling industry; the only thing that regulations gained here was to reduce the rate of extermination. In general, the sea-fishing industries of the world present many complications so far as conservation is concerned, especially the question of replacement of the life-giving plankton. On land, over-grazing is often a serious threat to animals; however, some scientists hold the theory that in some cases artificial control is unnecessary, stating that it is effected by natural causes in the long run.

Dr. Harrison Matthews refers to the population dynamics of certain classes of mammals, and gives an account of the catastrophic 'crash' that invariably arrives after a peak in numbers has been reached, especially in vole-plagues. The over-crowding of the immediate environment that occurs tends to result in psychological tension which eventually causes dysfunction of the adrenal gland; the breakdown of adrenal function causes the rapid death of the animals.

A recent inquiry shows that in 1958 the world population increased by 47 millions; at this rate, in forty years time the human population would double. It is unlikely, however, that this will occur as the growth of the human population tends to become slower and reach a stable level with the increasing standards of living. If we compare the present build-up of population with the cyclic build-up of the population of small mammals, it would seem that we are rapidly approaching the peak and the catastrophic 'crash'. Other factors are also likely to control the growth of population, such as atomic war and its radioactive contamination of the atmosphere, social control by inhibiting fertility in either sex, or the emergence of new epidemic diseases.

Dr. Harrison Matthews points out that the conservation of the world's fauna must be planned on a world-wide scale. It must be decided what parts are to be developed for human occupation and what parts are suitable for conserving fauna; already a number of national and international bodies interested in conservation exist; however, as such there has been only little action. He sums up by advising all zoologists to study any aspects of biology of the larger animals before it is too late.

TRENDS IN URBAN EXPANSION

LARGE-SCALE urban growth, which was a feature of nineteenth-century industrial development in western Europe and eastern North America, is the theme of the presidential address to Section *E* (Geography) by Prof. K. C. Edwards. It has continued to the present day, affecting almost all parts of the inhabited world. Recent decades, however, have witnessed a sharp acceleration of the process and urban expansion is now going on at an unprecedented rate. While industrialization remains a primary factor, it has come to play a relatively less important part in the crowding of people into cities.

Owing to the lack of a common definition among different countries as to what constitutes an urban population, precise measurement of the rate of urban growth for the world as a whole is impracticable. Some idea of its magnitude over the past half-century so far as large towns are concerned, that is, those of 100,000 inhabitants or more, can be obtained from the figures in Table 1.

Table 1

	No. of towns of 100,000 inhab. or more	Size groups (population in thousands)				
		100–250	250–500	500–750	750–1,000	More than 1 million
1910–13	322	200	63	33	8	18
1950–53	1,071	611	299	67	32	62

Not only has the number of large towns more than trebled, but also a marked upward trend in their mean size has occurred. The most spectacular evidence of urban growth is afforded by the millionaire cities. There are now about ninety of these vast agglomerations, of which London and Paris were the only examples a century ago, and their number increases yearly. Some 200 million people now live in these huge cities, and the day is not far off when they will shelter one-tenth of all mankind.

Yet the mammoth cities and existing conurbations do not represent the ultimate stage in the process of urban accretion, for in certain instances groups of these tend to coalesce, forming vast continuous urban areas to which the term 'megalopolis' has been given. The outstanding example is the virtually continuous urban belt stretching for 400 miles from Boston to Washington, D.C., containing more than 30 million people.

Whether in the older regions of settlement or in those of newer development, the expansion of cities is mainly due to the movement of people from rural areas and from the smaller to the larger towns. The townward drift is primarily the expression of a desire for improved conditions of life. In the process no new equilibrium between rural and urban populations is discernible, for food production, despite a dwindling labour force (except in south-east Asia), is increasingly dependent upon technical advances in agriculture. To-day the essential relationship is that between urban demands and agricultural productivity.

The latest phase of urban expansion has had significant effects upon the individual city. The rising importance of service functions of all kinds has substantially altered the structure of urban employment; the growth of administrative and other non-productive activities has intensified the use of the central business quarter; the demand for office accommodation in particular has increased the pressure on building sites, leading to an acceptance of the tall building for such purposes, often in defiance of tradition; retail services have become hampered through traffic congestion and competition for space, resulting in an increased emphasis upon secondary shopping centres in residential districts. In connexion with these and other changes, the controlling factor is motor transport. Its effects are both centrifugal and centripetal, and the capacity of the city to discharge its functions satisfactorily will increasingly depend upon the solution of problems to which this form of transport gives rise.

HOW MUCH SCIENCE ?

THE recent campaign in Great Britain for increasing the proportion of our human and material resources engaged in science, in all its forms, has been supported by a wide range of arguments, some of which are of doubtful validity. What tests can be applied to determine if and when there is a shortage of scientists ? It is with this question that Prof. J. Jewkes commences his presidential address to Section *F* (Economics). To the economist the term 'shortage' has an exact meaning. There is a shortage when, at the existing price, the demand is greater than the supply. Although the evidence is scrappy, the indications are that there is no shortage of scientists, in this specific sense, in Great Britain at present. For the salaries of scientists are not at a level nor moving in a direction which suggests shortage; nor do the latest estimates of probable supply and demand indicate any serious gap between the two.

It is frequently suggested that there is, nevertheless, an 'unmet need', implying that those who exercise the demand for scientists are not sufficiently conscious of their value to the community. Unmet need is an elusive concept, but four reasons have been given for believing that it exists. First, it is said that Britain is lagging behind the United States and the United States behind the U.S.S.R. These international comparisons, when they include the U.S.S.R., are for the most part hazardous statistical exercises with non-comparable material. Even in the comparisons between Great Britain and the United States many obstacles exist, both as to method and materials. It seems to be a reasonable assumption, however, that having regard to their populations, there is no great disparity between the two countries. Secondly, efforts have been made to establish correlations between the rate of change of industrial output and of the number of scientists and technologists in industry. But the statistical material employed here and the deductions based on it both seem to be unsatisfactory. Thirdly, it is sometimes suggested that since some industries spend on research and development relatively more than others, this proves that the second group is lagging. Fourthly, attempts have been made to measure the net gains arising out of expenditure on research and development; the results obtained in this way are interesting but do not support any very spectacular conclusions.

The scale of scientific activities in the community is determined by a very puzzling combination of public and private views, public and private actions and, in the last resort, the striking of the right balance will inevitably be a matter of informed guesswork and of intuition. At the moment the final judgment is probably being distorted by the tendency to exaggerate the part that science has played in raising the standard of living in the past; to overstress the potential material benefits of the more spectacular recent scientific discoveries; and to belittle the contribution made to economic expansion by skills and capacities non-scientific in character.

THE CRITICAL IMPORTANCE OF TRANSPORT AND COMMUNICATIONS

IN the modern world, transport affects the citizen and the engineer at every turn. In Britain, about 25 per cent of the gross national product is accounted for by transport and communications. Not only is the modern State utterly dependent for its daily bread on transport, but also its competitive power depends largely on its efficiency in operation. Moreover, it is one of the most easily observed aspects of a country's organization and achievement, and it has a psychological as well as a material impact. The subject bristles with technical, economic and political problems, but the aim of Sir Ewart Smith's presidential address to Section *G* (Engineering) is to express some very general thoughts as a challenge to our sense of urgency.

In the mid-nineteenth century, Britain had the best transport system in the world; this was largely the creation of engineers, who not only invented, designed and constructed in the technical sense but also often organized the business sides of the ventures

they had conceived. When, to-day, we compare land transport at home and abroad, we must admit that we have not applied either the technology or the money necessary to keep up with the general advance.

Although very recent years have seen some awakening of Britain to its transport needs, a few facts and figures may be mentioned to underline the need for still greater boldness in plans and expenditure.

The projected expenditure of £60 million on new roads and major improvements is no more than the 1939 rate, allowing for the fall in the value of money, though the number of vehicles has grown from 3 to more than 7 million, and is increasing at 8 per cent a year. While attention is now being paid to motorways, by the end of 1959 only 64 miles will be in use, whereas between 1830 and 1850 new railway routes were being built in Britain at an average rate of 320 miles a year. Urban road development lags even more. We have no established centre for training high-grade traffic engineers, although the savings to be gained from traffic engineering are immense. An increase of only 5 m.p.h. in average speeds—at present 20 m.p.h. in urban districts and 32 m.p.h. in rural—would give an economic saving of at least £180 million a year, and much more as traffic grows.

The railways, too, suffer greatly from past neglect of capital expenditure and technical recruitment. During 1900–55 true capital outlays were very small, and as late as 1956 only 0·23 per cent of the employees of the British Transport Commission were qualified scientists or engineers. In comparison, in the National Coal Board the proportion was 0·7 per cent, in the Central Electricity Authority 2·9 per cent, and in the Atomic Energy Authority 10·9 per cent. The British Transport Commission is making valiant efforts to retrieve the position, and the results are likely to be striking. Nevertheless, even bolder thinking is desirable, particularly in regard to size of wagons and turn-round (wagons now average only 10 miles/day). It must be stressed that in this the users have major responsibilities as well as corresponding opportunities of gain.

In transport abroad, and in our newer and progressive industries, scientific engineers play a much larger part than in the road and rail transport organizations of Britain; we need to train more and use them more widely. We must remedy the defects in the transport system of Britain, particularly on the roads, by far greater capital expenditure and by a bolder approach to the technical and organizational problems involved.

ARTIFICIAL ORGANS: BIOLOGICAL APPLICATIONS

WE are reminded by Prof. A. Hemingway, in his presidential address to Section *I* (Physiology and Biochemistry), how much the study of isolated organs and tissues maintained under conditions ensuring survival has yielded to the physiologist. These tissues are immersed in, or superfused (a new technique), or perfused with blood, serum or solutions which may be regarded as 'artificial bloods'. A solution in which the ionic concentrations of sodium, potassium and calcium were adjusted to maintain conduction and contraction in cardiac muscle was first introduced by Ringer; but since his day many modifications have been made, including the addition of metabolites such as pyruvate and glutamate. To make a blood substitute for clinical use as an 'expander' after hæmorrhage or in post-operative hypotensive states, dextrans of appropriate molecular size have been prepared and added to these solutions to make them osmotically equivalent to plasma. But, so far, it has not been possible, except by employing suspended red blood corpuscles, to make these solutions adequate carriers of respiratory gases.

The introduction of antibiotics and ample supplies of anticoagulants have encouraged and established the use of perfusion and similar techniques for clinical purposes. The 'artificial kidney', which has proved successful in the management of certain types of kidney disorder, is a development of Abell's (1922) vividiffusion apparatus. The principle is that an artery is cannulated and the blood, rendered incoagulable, is passed through a 20–30 m. length of 'Cellophane' tubing which is formed into a spiral and rotated in a bath of modified Ringer's solution. According to differences in concentration across the membrane, substances will be interchanged between the blood and the surrounding fluid. By this means, substances which have accumulated because of renal dysfunction can be removed from the blood; the rate and the extent of the exchanges can be controlled by regulating the composition of the surrounding bath. Ensuing chemical changes in the blood must be followed. Treatment by the 'artificial kidney' is indicated when the pathological changes in the kidney are reversible and the patient's kidneys are likely to resume their functions.

In the field of cardiac surgery more extensive and complicated operations have been made feasible during the past decade by the development of the 'extracorporeal circulation'. This is a method, based on techniques well established in physiological laboratories, by which the systemic circulation of the body can be maintained by a mechanical pump and a blood oxygenator for a period during which the heart and the lungs of the patient can be by-passed. The heart and its neighbouring vessels can then be opened and congenital abnormalities or valvular lesions repaired or modified. There are many problems in the design of pumps and oxygenators which, while giving, respectively, adequate flow of blood and sufficient exchange of respiratory gases, will not injure the blood. Striking clinical progress has already been made and it seems likely that the improvements in the technique of perfusion will be applied to further studies of organ function and control and, probably, of survival *in vitro*.

PERCEPTION, ATTENTION AND CONSCIOUSNESS

IN her presidential address to Section *J* (Psychology), Prof. Magdalen D. Vernon points out that we can never be aware at any one moment of the whole of our surroundings. The degree to which we are aware of them varies greatly, from a precise perception of a narrow central field of view upon which attention is focused, to a vague awareness of all other parts. We can vary the amount of attention and the accuracy of perception from moment to moment, and direct it to different parts of our surroundings; but the area of the field, and the number of events or objects in it, of which we can be aware at any one moment are limited. Focal awareness of one part of the field may preclude the perception of surrounding parts. It appears to be possible, however, to perceive

events without being immediately aware of them and to store the information and attend to it later; but such information cannot be retained for long. However, there is evidence to show that even when such information never reaches consciousness, it may yet have some effect on thoughts and behaviour.

Various factors operate to produce a selection of what is perceived and attended to most closely. We tend to perceive primarily what we expect is most probable to occur in the circumstances; and our previous experience of similar situations does much to determine the estimation of probability. However, expectation is also affected by the reception of special instructions and information, and by training in what to look for. People may also tend to perceive readily what they desire to perceive or are interested in perceiving; but in such circumstances they may imagine they see what is not actually there. Again, they may be unusually slow to perceive what would be disagreeable to them. But they quickly become aware of sudden and unexpected events which are significant and perhaps potentially dangerous, although they may be slower to perceive fully the exact nature of these events.

It is difficult to perceive anything which is exposed only momentarily, or in very dim illumination, or in the margin of the field of vision. Nevertheless, there is some evidence to show that material exhibited below the normal threshold of vision, of which the observer is not directly conscious, may in some circumstances affect his thoughts or behaviour, and in particular produce reactions of the autonomic nervous system. Attention tends to wander after a time from events of no great interest which recur repeatedly and monotonously, and they may cease to be perceived. A long period of exposure to completely homogeneous surroundings produces a decrease in awareness and the power of discrimination, accompanied in some cases by hallucinations and unpleasant emotional reactions.

Recent physiological evidence as to the nature and functions of the reticular formation in the sub-cortical regions of the brain suggests that impulses from this formation may stimulate the cortex in such a way as to produce both a general arousal of consciousness; and also the direction of specific awareness to events of particular significance to the individual. Cortical impulses in turn may facilitate these activities of the reticular formation, or may inhibit them, for example, in situations associated with the withdrawal of attention, such as those of repeated unvarying stimulation of no interest or importance to the individual. Clearly these findings have considerable significance in relation to the psychology of perception and attention, though our understanding of their exact bearing must await further investigation.

PLANTS ON LAND AND IN THE OCEANS

FOR his presidential address* to Section *K* (Botany), Dr. W. R. G. Atkins prepared an account of the many and varied problems on which he had worked and for which his initial training as a botanist had proved invaluable. Starting with a brief account of his work on the suitability and preservation of the timber and fabrics used for the aeroplanes of the First World War, he passed on to an account of his work after the War for the Imperial Department of Agriculture in India. It was in India that he started his studies on the *p*H of soils and plant juices, work which he later extended in Britain. After his appointment to the staff of the Plymouth Laboratory of the Marine Biological Association, he was able to use *p*H measurements for assessing the total quantity of photosynthesis in water masses in the sea and to initiate complementary chemical hydrographical work at the International Hydrographic Station *E*1—work which has been continued by the staff of the Plymouth Laboratory ever since.

Dr. Atkins then gave an account of his extensive investigation into the penetration of light into the sea, a factor of great importance for the growth of the phytoplankton. These studies were later extended to include measurements of light scattering and of the nature of the light fields to which plants in various environments are subject, both in air and under water. In addition to this work, his interest in the plants of the phytoplankton continued. Anomalies were often apparent when the crop of phytoplankton was estimated from measurements of the utilization of different nutrients. That these anomalies were due to the occurrence on occasion of unsuspectedly large amounts of non-siliceous species was suggested by Dr. Atkins—a hypothesis that his later observations and those of other workers have amply confirmed.

Curious delays in the time of the spring outburst of the phytoplankton when determined by the sudden reduction in phosphate in the water mass were also sometimes observed. These delays did not seem to be due to physical factors, since both the light and temperature were apparently suitable for rapid plant growth. A study of the concentration of silicate and of the various species occurring in the water indicated a sudden influx of a fresh water mass into the area—a phenomenon not apparent from records of the temperature, salinity and phosphate, nor from measurements of the total plant population as measured by chlorophyll estimations. Thus, after thirty years, at least one good reason for the lateness of the phytoplankton crop had become evident. This, however, is not to say that at other times and places changes in the vertical circulation or other factors may not be important. It does, however, indicate the value and necessity of the close integration of studies concerned with the concentration changes of all the known nutrients, the physical factors involved and both the total plant population and the occurrence of individual species.

* Prepared from notes left by Dr. Atkins and read posthumously by Dr. C. P. Spencer, of the Marine Biology Station, University College of North Wales, Bangor.

PATHOGENIC FACTORS IN THE ROOTING SPACE AND THE DEVELOPMENT OF EVEN-AGED PLANTATIONS

IN his presidential address to Section *K** (Forestry), W. R. Day says that the distribution of species of tree within the range grown for economic purposes is closely related to productive capacity as determined by available site types: adequate freedom from acutely damaging infestations and freedom from infections are, plainly, related necessities. Production is based on growth as a natural biological process and its economic value depends partly on rate of growth and partly

on quality of production as determined by market value of produce or services rendered. Ordinarily, the development of the main stem provides the principal interest in production, and this is governed by the interaction of crown and root as functioning correlatives. Given adequate climatic adaptation of species of tree, then, within any suitable limited climatic range, the more important basic environmental variations which determine variations in production-rate are to be found in soil conditions as affecting root growth and functioning.

The general tendency in development in forests established as even-aged regenerations is from simplicity towards complexity in canopy structure; the rate of development of this tendency for any given species of tree and assuming relative evenness in climatic conditions is largely a function of the soil conditions which prevail locally. The factors which determine the course of development in canopy structure are partly to be found in sylvicultural treatment, but basically in the developing demand by the forest canopy as crowns increase in size, especially during the first decades after regeneration, with reduction in number of stems per unit area and increase in height of tree; and according as this demand can be satisfied by supply of root growing-space as qualified by available water and nutrients. Potential demand of a canopy of any given specific composition, according to size of tree and as influenced by stand density, may be considered as a genetic characteristic. Since the degree to which this potential demand can be satisfied is determined largely by soil supply conditions it follows that, for any given age and type of even-aged regeneration, variations in canopy development which are natural to the site will occur according to the distribution of variations in the stage of stand development at which volume of canopy demand becomes marginal with site supply and especially with supply from the root growing-space. Examples taken from even-aged Sitka and Norway spruce stands are given which illustrate variations in stand structure determined in this way. Limitations in edaphic supply necessary for root development and action arise from a complex of physical, chemical and biotic factors the action of which is more or less interrelated. Examples based mainly on the physical aspect of clay and sand soils, as observed in the field, are given to illustrate edaphically determined limitation in supply which, through the prevention of growth naturally attempted, acts as a basic cause of disease and in this way influences stand development and, through this, economic production.

Examination of the problem of management of even-aged plantations suggests that if the effects of technical sylvicultural treatments are sufficiently to be appreciated, there must be some adequate understanding of the locally occurring inter-relationships between canopy development and site supply of the needs for this; for this, through basically controlling the type of growth possible, will largely determine the effectiveness of the technical treatments practised.

WHAT ARE OUR SCHOOLS FOR?

SIR JAMES J. ROBERTSON, president of Section *L* (Education), opens his address by pointing out that it was only within a few weeks of each other that a Scottish judge and the Home Secretary spoke last winter about increased crime and irresponsibility. They called for greater help from the schools, only to be rebuked by leading educational journals, which put the blame on bad influences outside. Such criticisms focus widespread confusion about the schools' functions and society's ability to protect itself.

Our educational philosophy is admirable, but our practice belies our professions; and, while within the task allotted to them our teachers merit respect and commendation, no part of our national education, except our enlightened infant departments, justifies complacency in face of the crisis of our time. Admittedly, the ablest pupils in our grammar schools are equal to the demands made on them. But do we allow time for their knowledge to be fully assimilated? To what extent do we quicken sensibility in them, or nourish imagination, or awaken the sense of dependence on others? Moreover, if we segregate the highly gifted in separate schools at eleven, do we not aggravate the risk of producing 'Lucky Jims' or an arrogant self-appointed élite?

The average grammar school entrants, supposedly most fortunate, are educationally the worst used of all. Despite advantages in staffing and provision, they are the victims of an unsuitable curriculum and an external examination too hard for the majority. They suffer from excessive demands on their time, a low level of real attainment, an obsessional concern with examinations, and deplorable neglect of the non-cognitive sides of their natures. The vision of the Norwood Committee and the Scottish Advisory Council quickly died amid post-war careerism and greed.

Equally deplorable is the largely lost opportunity in the secondary modern schools, with the discrediting of interest and experiment and the ever-increasing participation in the chase after certificates, a participation which can, however, be defended if the General Certificate of Education really matters as much as we pretend, and we put into secondary moderns children capable of securing even scrappy certificates.

The bright promise of 1943 for the primary schools also faded swiftly in the universal scramble for status. A secondary education like that in Britain presupposes a primary, geared to '11 +', with tests and streaming all the way and those pressures that make short work of frills and experiments. Add the excessive size of classes and general inadequacy of provision, and you ensure the dominance of class-teaching and the rigid time-table, with disastrous consequences both to secondary schooling and to any further education adequate to our condition.

Further education which is neither vocational training nor purveyed entertainment is at once the most important of all, and in its meagre extent the most disappointing. How can it be otherwise so long as statutory schooling creates distaste and does but scant justice to music, drama and the arts?

Education in Britain accords as ill with recent thinking and discovery as with the sombre realities of our times, taking insufficient account of the rarity of high intelligence, the great range of innate ability and the powerful movements of thought towards an organic and unitary view of man as existent and person. Our great need is to awaken to the costliness, both material and spiritual, of all true education: reform must begin with a national change of heart.

BALANCE IN BRITISH FARMING

DR. H. G. SANDERS suggests in his presidential address to Section *M* (Agriculture) that the forty-seven years life-time of the Section has seen science applied to British agriculture at an ever-increasing rate, and there have also been violent economic changes. Farming systems which have been built up in more leisurely times have achieved a balance which might be upset by these scientific and economic impacts. There has clearly been an improvement in some aspects of the really basic factor—soil fertility. The lime status of the soils of Britain has been raised markedly and is still improving, and the increasing use of chemical fertilizers has led to better plant nutrient content. In regard to drainage the situation is less satisfactory. There is still uncertainty and much argument over the importance of maintaining the organic matter content of the soil, the danger being that, if it is allowed to fall, soil structure will be lost. New chemicals have proved powerful aids in keeping land clean, but there are obvious dangers in their indiscriminate use. On many farms the ley has replaced the root crop as the pivot of the rotation, and advanced practitioners are showing how great the production from newly established grass can be. Full summer utilization necessitates conserving surplus herbage at peak periods of growth, and silage fits better into advanced grazing control than hay. Much is known about the extra cost involved in making high-quality hay and silage, but little about the increased animal production from first-class material and its possibilities in economizing expensive concentrated foods. There is urgent need for more applied research into such problems.

One aspect of balance in traditional farming systems has been the relation between the feeding-stuffs produced from the land and the head of livestock maintained. A high degree of self-sufficiency is still a sensible economic aim, but its attainment depends on high-quality roughages and more precise knowledge of their potentialities, not only as maintenance ration but also for animal production.

A rough balance in the farming of Britain as a whole has grown up in a somewhat haphazard way. Sales of store sheep in Scotland are well established, and similar ones for store cattle have recently started and are developing rapidly on the Welsh border. The reverse movement of grain and straw from east to west is unorganized and depends on the initiative of individual merchants. British farmers have had outstanding success in the development of pedigree livestock, but the future will probably see more use of crossbreds for commercial exploitation. In poultry this is already widespread and in sheep also, though with them the benefits are often lost by continuing and indiscriminate crossing. The development of a system of pedigree breeders and crossing breeders to provide livestock for the ordinary farmer would help in the simplification of farming which advancing knowledge is making ever more necessary. The ultimate solution of this problem of keeping abreast with science should not be monoculture, but mixed farming with the more scientific processes in the hands of specialists.

THE ST. LAWRENCE SEAWAY AND POWER PROJECTS: GEOGRAPHICAL BACKGROUND

By Prof. T. L. HILLS
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THE official opening of the St. Lawrence Seaway on June 26 brought to completion five years of design and construction of both the Seaway and Power Projects on the St. Lawrence River. It also brought to fruition more than fifty years of almost incessant agitation in both the United States and Canada for the development of a deep navigable waterway into the heart of the North American continent. Yet most significant of all, it will carry one stage further a process that has been under way for nearly four hundred years, since Jacques Cartier was halted in his journey up the St. Lawrence by the Lachine Rapids. This process has involved on one hand the gradual exploitation of physical features of the Great Lakes–St. Lawrence drainage system advantageous to navigation, and on the other, the overcoming of natural obstacles to navigation. Successive stages in this process have reflected the economic development of the continent as well as political changes. The St. Lawrence Valley is the natural outlet of the continent to the North Atlantic and western Europe; therefore, improvement of this waterway was to be expected. However, nearly four centuries since European man first arrived on the scene the navigation facilities on the St. Lawrence have only just been improved to the point where ocean-going vessels of more than 2,500 tons can be accommodated. These navigation facilities are still not comparable with the other great canal systems of the world. At present, the Panama, Amsterdam, Rhine, Kiel, Suez, Texas and Manchester Ship Canals all exceed in size the proportions of the St. Lawrence Seaway facilities. For an explanation of the long delay in the 'coming to age' of the navigation facilities throughout the Great Lakes–St. Lawrence system, geographical, historical, economic and political factors must be considered.

The St. Lawrence River system in combination with the Gulf of St. Lawrence and the Great Lakes provides a continuous waterway extending 2,347 miles into the heart of the North American continent from the Atlantic Ocean. The length of this waterway, its location and orientation, are three of its outstanding geographical characteristics. Mere length alone is not necessarily an economic attribute. However, in this case the distance of the penetration into the continent, which is comparable with the great circle route distance between west European ports and the estuary of the St. Lawrence, is of the very greatest economic significance because the Great Lakes–St. Lawrence system provides an approximate east–west routeway into the heart of one of the richest agricultural and industrial regions on the face of the Earth, a region lying due west of the metropolis of Europe and the British Isles. In relation to resource production and potential this routeway is ideally located. Its hinterland or contributory region, comprising as it does the Canadian Shield, the greater part of the Interior Lowlands and parts of the central and northern Appalachian System, is extremely rich in agricultural, forestry, mineral and water-power resources. It was natural that one of the world's major trade routes should develop between such a region and a heavily industrialized and densely populated Europe.

The St. Lawrence River provides the only completely natural water gap through the mountain and upland barrier formed by the Appalachians and the south-eastern upturned edge of the Canadian Shield; but for only brief periods in the past four centuries has it been the chief transportation route between the Atlantic and the interior of the continent. The St. Lawrence has faced competition from Hudson Bay, the Mississippi Valley, the Pacific Coast–Panama Canal route and especially the Lake Erie–Mohawk–Hudson route. The economic and political history of the St. Lawrence can largely be told in terms of its continued competition with the alternative routeways from the interior of the continent. The low-level link between Lake Erie and the port of New York provided by the valleys of the Mohawk and the Hudson gained the ascendancy over the St. Lawrence route with the completion of a barge canal between Buffalo and Albany in 1823. The ascendancy resulted partly from a major physical advantage of the more southerly route, and partly from the fact that it was an 'all-American' route between the Middle West and Europe.

The major physical advantage of the Lake Erie–New York route is the year-round ice-free condition of the port of New York. Inherent in the location of the St. Lawrence, a location which in all other respects has proved advantageous, is one of its most serious limitations. The winter climate of a region so located in the north-eastern quadrant of a continent within the northern hemisphere is long and extremely cold. Below freezing temperatures for at least four months result in the St. Lawrence being turned into an ice-way rather than a waterway. From the year 1887 until the present day the average date on which the ship channel between Quebec and Montreal has been open for navigation has been April 17; the earliest date throughout that period was March 19 and the latest date May 1. The average date of the last departure from Montreal was December 4, the earliest was November 21 and the latest December 19. Amelioration of conditions during the past decade and more recently assistance from icebreakers have resulted in the lengthening of the navigation season by about two weeks. With the completion of the Seaway it has been suggested that the navigation season might well be even further lengthened by an increase in the number and the efficiency of ice-breakers, the use of aerial ice surveys and the improvement of aids to navigation.

An eight-month navigation season on the St. Lawrence and the Great Lakes compared to year-round navigation on the Atlantic coast south of the Gulf of St. Lawrence has probably militated against the development of the full potential of the St. Lawrence and the Great Lakes more than any other factor, though if deep navigation had been more readily available this limitation would perhaps not have been considered quite so disadvantageous.

The other major physical limitation of the Great Lakes–St. Lawrence waterway has been, of course, the series of falls, rapids and shallow connecting channels, which unfortunately abound within the system, especially between Montreal and Lake Huron. The long delay in successfully circumventing these

obstacles has not been due to engineering difficulties but rather to the sheer expense involved. In the upper St. Lawrence, that is between Montreal and Lake Ontario, all the pre-Seaway canalization was undertaken by Canada, at an expense which was very considerable for a relatively small and youthful country. Only in recent years when it became feasible to merge schemes for the provision of navigation facilities and the development of hydroelectric power did the expense appear not too burdensome, for both Canada and the United States. It is fortunate that the most serious liabilities of the whole Great Lakes–St. Lawrence system are, at one and the same time, very great assets. The upper St. Lawrence, which has over the years proved the most serious obstacle to the improvement of navigation, to-day provides almost 4,000,000 horse-power of electricity.

The natural deep navigation throughout much of the Great Lakes and on the lower St. Lawrence and the falls and rapids, seen either as obstacles to navigation or as water-power sites, owe their existence to a varied geological and physiographical history. The entire drainage system of the Great Lakes and the St. Lawrence covers an area approximately 678,000 square miles in extent, within three of the major geological and physiographical regions of the continent: the Interior Lowlands, the Canadian Shield and the Appalachians. The Great Lakes and the valley of the St. Lawrence lie chiefly within the north-eastern section of the Interior Lowlands. Here a great series of Palæozoic sedimentary rocks, primarily limestones, dolomites, shales and sandstones, take a basin-like form, overlapping on to the rocks of the Shield and the Appalachians to the north and the east. Differential erosion on these Palæozoic rocks has produced a series of cuestas best typified by the famous Niagara Escarpment, and lowlands, which are to-day partly occupied by four of the Great Lakes and sections of the St. Lawrence Valley. In general, dolomites and limestones tend to form the higher parts of the region and are the 'fall-makers', while the shales have been removed extensively to form the lowlands and particularly the four lower lake basins. Lake Superior lies entirely within the Precambrian rocks of the Canadian Shield. The Great Lakes probably owe their origin to a combination of events—structural depression, fluvial erosion, glacial deepening and morainic damming. These events gave rise to the great size and depth of the Great Lakes. The deepest point in Lake Superior is 1,302 ft., that is, 700 ft. below sea-level, while Lake Michigan has a maximum depth of 923 ft., Lake Huron 750 ft., Lake Ontario 774 ft.; Lake Erie is relatively shallow, with an average depth of only 58 ft. The water surface of the Great Lakes covers an area of 95,000 square miles, an area almost as great as that of the British Isles.

The surface of Lake Superior averages 602 ft. above sea-level. The drop to sea-level is concentrated in two sections of the drainage system: between Lakes Erie and Ontario and in the upper St. Lawrence between the outlet of Lake Ontario and Montreal. There is a total drop of 326 ft. from Lake Erie to Lake Ontario, with a vertical drop of 168 ft. at Niagara Falls, where the outflow of Lake Erie drains across the resistant Lockport dolomite of the Niagara Escarpment. Between the outlet of Lake Ontario and Montreal the St. Lawrence drops a total of 246 ft. in a distance of 183 miles, and in doing so flows across alternating resistant igneous and weaker sedimentary rocks, which has given rise in turn to a series of alternating rapids and lake basins. Immediately on leaving Lake Ontario the St. Lawrence flows across a southerly extension of the Canadian Shield, the Frontenac Axis. This section is known as the Thousand Islands; it is wide, deep and free of rapids. Below it a series of four rapids, collectively known as the International Rapids, because here the Canada–United States border runs along the St. Lawrence, provide a drop of 92 ft. in a distance of 44 miles. These rapids, including the famous Long Sault, have to-day disappeared under the power pool of the St. Lawrence Dam. Here the engineers won a brilliant victory over the St. Lawrence by raising the waters of the river 81 ft. behind a dam built below these falls. They have developed tremendous water-power and at the same time provided excellent deep navigation which replaces a series of four 14-ft. deep canals of the old St. Lawrence canal system.

Downstream from the International Rapids section Lake St. Francis drains via another series of four rapids with a total drop of 82 ft. Again this major obstacle has been circumvented by a combined power pool and deep waterway known as the Beauharnois Canal. Here again there is a potential 2,000,000 horse-power of electricity, three-quarters of which has already been developed. The final major drop of the St. Lawrence occurs where Lake St. Louis drains over the Lachine Rapids. The drop of 50 ft. has not yet been harnessed for the development of electric power, and the Lachine Rapids have remained solely as an obstacle to navigation. They have additional geographical significance in that the city of Montreal has developed largely as a result of the Lachine Rapids bringing natural deep navigation to an end at this point.

The value of the many considerable drops in elevation within the Great Lakes–St. Lawrence system as water-power sites is considerably enhanced by two additional physical attributes of the region. The Great Lakes in particular, but also the myriads of large and small glacial lakes within the Canadian Shield, act as vast reservoirs with a tremendous storage capacity which results in the outflow not only being considerable but also in being regulated to a remarkable degree. The maximum average flow is about 310,000 cu. ft. per sec. and the minimum 144,000 cu. ft. per sec. The variation of about 2 to 1 is in striking contrast to the flow of the Columbia River, with a ratio of 35 to 1, and the Mississippi River, with a ratio of 25 to 1. The average flow in cu. ft. per sec. obviously increases downstream, being 71,000 between Lakes Superior and Huron, 194,000 on the Niagara River, 237,000 in the International Rapids section, and it reaches a maximum volume of 262,000 cu. ft. per sec. where the Ottawa River joins the St. Lawrence. The relatively uniform annual precipitation within the drainage basin also contributes to the uniform flow and the tremendous volume of water in the system. Precipitation varies from 25 to 43 in., with a mean of 33 in.

The completion of the combined St. Lawrence Seaway and Power Projects brings to a satisfactory stage the development of navigation facilities on the Great Lakes and the St. Lawrence and brings closer the complete utilization of the tremendous water-power available. Man has long awaited the day when the full economic potential of this vast system would be realized. This stage may not yet have been reached, but economic and technological development will probably no longer hinder absorption of any remaining potential into the navigation and power systems of the Great Lakes and the St. Lawrence.

(*Continued from page 34*)

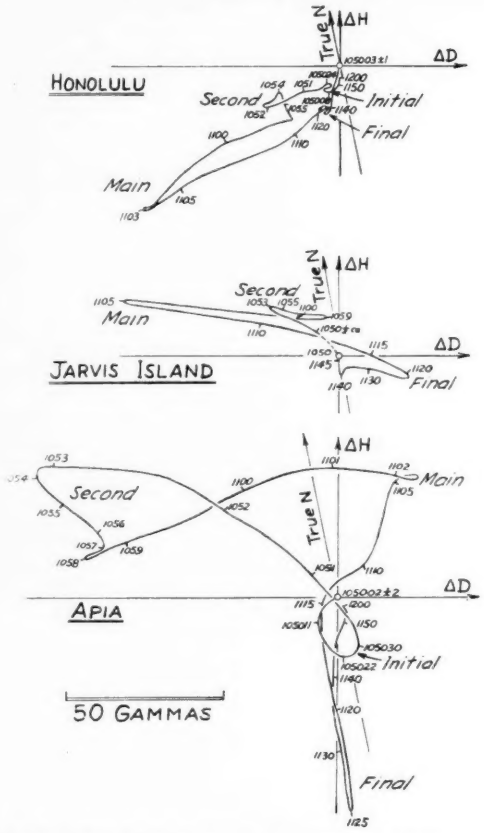

Fig. 2*a*. Vector diagrams showing the horizontal plane magnetic effects of the explosion of August 1. Times are G.M.T.

local *E*- or *F*-region winds in the area of increased ionization produced by these particles, particularly near the conjugate point.

Main phase. Gas motion due to the explosion which, by the time of maximum of this phase, extends to the region of the meridians through Honolulu and Jarvis Islands. G. A. M. King and C. H. Cummack (personal communication) independently propose a shock front spreading from Johnston Island with radially uniform horizontal speed. They associate the arrival of this at each station with the time of maximum of the main phase there, except at Apia, where they associate it with the time of maximum of the final phase.

Adopting the idea of a circular horizontal boundary centred on Johnston Island, applied to an expanding conducting cloud, we suggest a broad qualitative interpretation of the magnetic vectors as follows.

Fig. 3*A* shows the type of distortion produced in the horizontal magnetic field, assuming that the lines of force are to some extent frozen in the gas.

Fig. 3*B* shows a current system which might be produced by the e.m.f. induced in the northern section of the cloud moving against the Earth's vertical magnetic field, with return current moving preferentially along the meridian and linking up in the region of high ionization near the conjugate point.

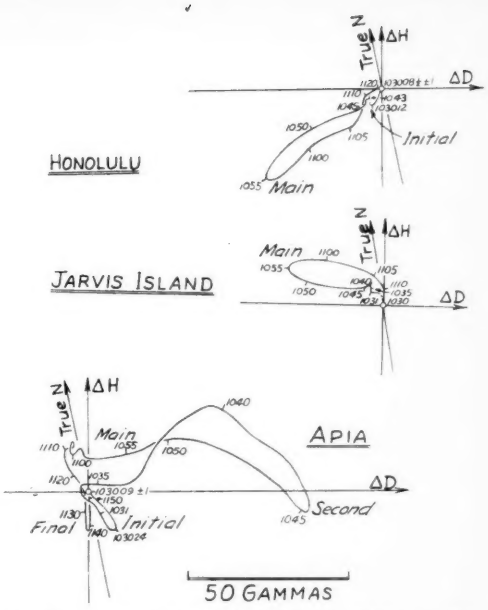

Fig. 2*b*. Vector diagrams showing the horizontal plane magnetic effects of the explosion of August 12. Times are G.M.T.

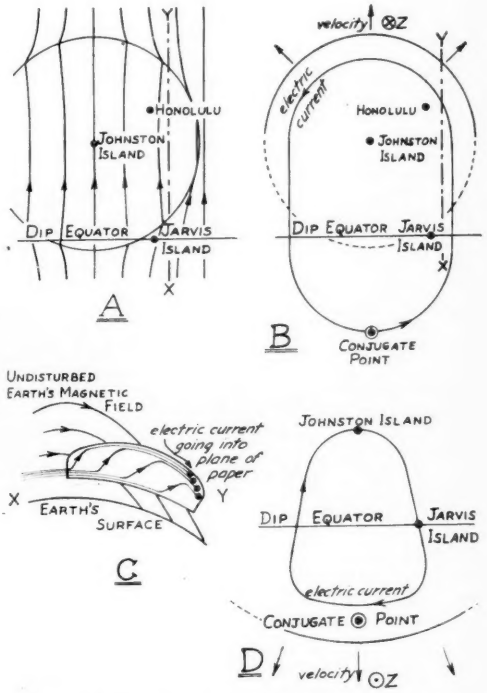

Fig. 3. (*A*) Distortion of Earth's horizontal magnetic field by expanding conducting cloud during the main phase. (*B*) Electric current induced by motion against *Z* of northern section of expanding cloud during main phase. (*C*) Current system in vertical plane across section *X*—*Y* to approximate distortion in (*A*) combined with the current system of (*B*). (*D*) Electric current induced by motion against *Z* of southern section of expanding cloud during final phase

Fig. 3*C* shows a vertical section across *X*–*Y* of Figs. 3*A* and *B*. In this is pictured a current system which is imagined to combine that of 3*B* with currents to approximate the distortion shown in 3*A*.

Note that the return current across the equator contributes to the required distortion, and we suggest that this as well as anisotropic conductivity control the direction of flow.

Final phase. A later development of the motion producing the main phase, corresponding to the passage of the shock front over Apia as postulated by King and Cummack. In Fig. 3*D* we suggest an interpretation of the magnetic vectors on this idea. This current system would depend on the abnormal ionization still situated in the whole region between Johnston Island and the conjugate point.

The development of all phases after the first explosion is faster, and affects a wider region, consistent with the belief that the first was the highest.

We hope to publish a full account of this work in the *N.Z. Journal of Geology and Geophysics*.

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[1] Cullington, A. L., *Nature*, **182**, 1365 (1958).
[2] Kellog, P. J., Ney, E. P., and Winckler, J. R., *Nature*, **183**, 358 (1959).
[3] Akasofu, S., Rep. Ionospheric Res. in Japan, **10**, 4, 231 (1956).
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Some Geomagnetic Phenomena associated with Nuclear Explosions

The three International Geophysical Year stations operated in the central Pacific by the Scripps Institution of Oceanography have consistently recorded magnetic disturbances following, and apparently caused by, the various nuclear tests conducted by the British in the vicinity of Christmas Island. This fact is particularly interesting because, unlike the American bomb which was exploded in the ionosphere over Johnston Island on August 1, 1958, producing auroral and magnetic effects over a large area of the Pacific[1], the British tests are believed to have occurred at relatively low altitudes in the lower atmosphere.

Fig. 1 shows magnetograms for the explosion of April 28, 1958, and Fig. 2 the positions of the observing stations relative to the shot point, which was stated to have been within ten miles of 1° 40′ N., 157° 15′ W. The altitude has not been disclosed, but official reports indicate that the device was dropped by a *Valiant* jet bomber, and it may be supposed that the height of detonation was substantially less than the ceiling of about 60,000 ft. for that class of aircraft.

The pronounced anomalies in *Z* and *D*, which reach a maximum at Jarvis and Fanning between 12 and 15 min. after the event and at Palmyra about 10 min. later, are similar in character to those which followed other tests, and we have no doubt that they are directly related to the nuclear explosion. We have examined magnetograms from the nearest magnetic observatories outside the immediate area,

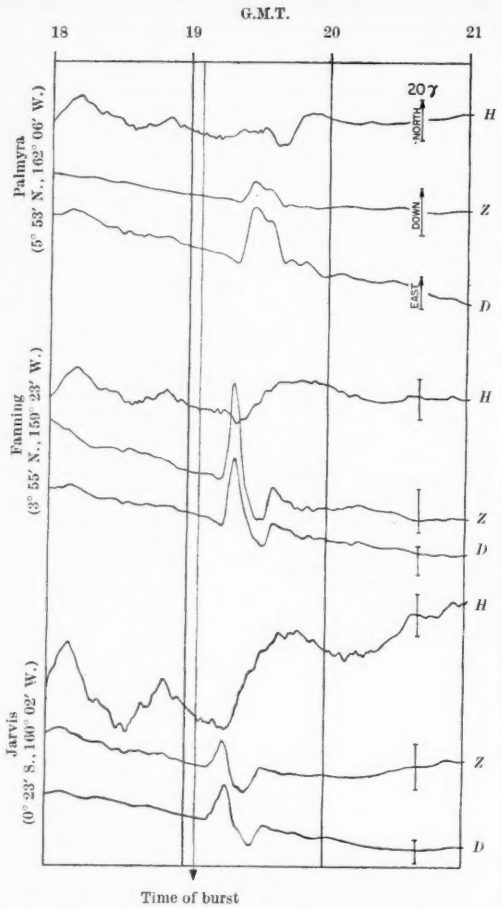

Fig. 1. Magnetograms for the Christmas Island nuclear explosion of April 28, 1958

that is, Apia, Guam and Honolulu, but have not found any magnetic effects that we can positively identify with this or with any other of the British tests. This is surprising, because Apia and Honolulu are only about three times as far as Palmyra from Christmas Island.

The disturbances recorded at our three stations have several features in common. They begin quite suddenly after a delay of several minutes (rather longer at Palmyra than at the other two stations), they move in the same relative phase and they persist for about half an hour, but perhaps the most striking feature of the magnetograms is the absence of any observable disturbance in *H* corresponding to the major disturbance in *Z* and *D* (though an unusual, and probably related, type of local disturbance in *H* at Palmyra commenced about 26 min. after the event and lasted for about 20 min.). The absence of an *H* component would be explained if the phenomenon involved horizontal currents parallel to the magnetic meridian, and in this connexion it may be noted that the Earth's magnetic field is very nearly horizontal throughout the area. More generally, possible mechanisms for producing such disturbances include: (*a*) the motion of charged particles, in certain circumstances controlled by the Earth's magnetic field; (*b*)

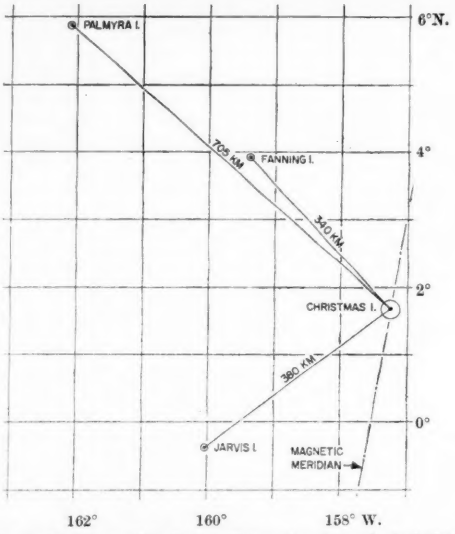

Fig. 2. Positions of the Scripps International Geophysical Year stations relative to the shot point near Christmas Island

the modification of existing ionospheric currents through displacement of the conducting medium or changes in conductivity; (*c*) the mechanical disturbance of a magnetic field frozen into a mechanically disturbed conducting medium. To these must be added the secondary effect of induction within the Earth.

In order to bring out more clearly the vector characteristics of the disturbances, diagrams have been constructed showing the time variation of their projections in various planes, measured as the departure of the observed field from an assumed smooth background (represented by the origin of the vector diagram). Fig. 3*a* shows diagrams for the vertical plane perpendicular to the magnetic meridian. The explanation of the large time delay at Palmyra is now seen to be that, although the vectors at all three stations reach peak values in one direction between 12 and 16 min. and in the opposite direction between 23 and 27 min., the directions and amplitudes of the two peaks at Palmyra are reversed.

Fig. 3*b* shows the corresponding diagrams for the Johnston Island explosion of August 1, 1958. Having regard to the altogether different geographical positions and altitudes of the two events, the similarity of the two sets of diagrams is remarkable. However, unlike the Christmas Island explosion, the Johnston Island event produced changes in H comparable in magnitude with those in D and Z. Fig. 4 shows vector diagrams of the disturbance in the horizontal plane, plotted to show the relative directions of the magnetic vector, Johnston Island and the conjugate point (taking Elliot and Quenby's position[2]) at each station. This event produced effects not observed in connexion with the Christmas Island tests, for example, an instantaneous change in H of about 10 gammas.

It is clear from the complicated nature of the Johnston Island disturbance, and from the extent to which it resembled the disturbance produced by the dissimilar Christmas Island event, that no simple

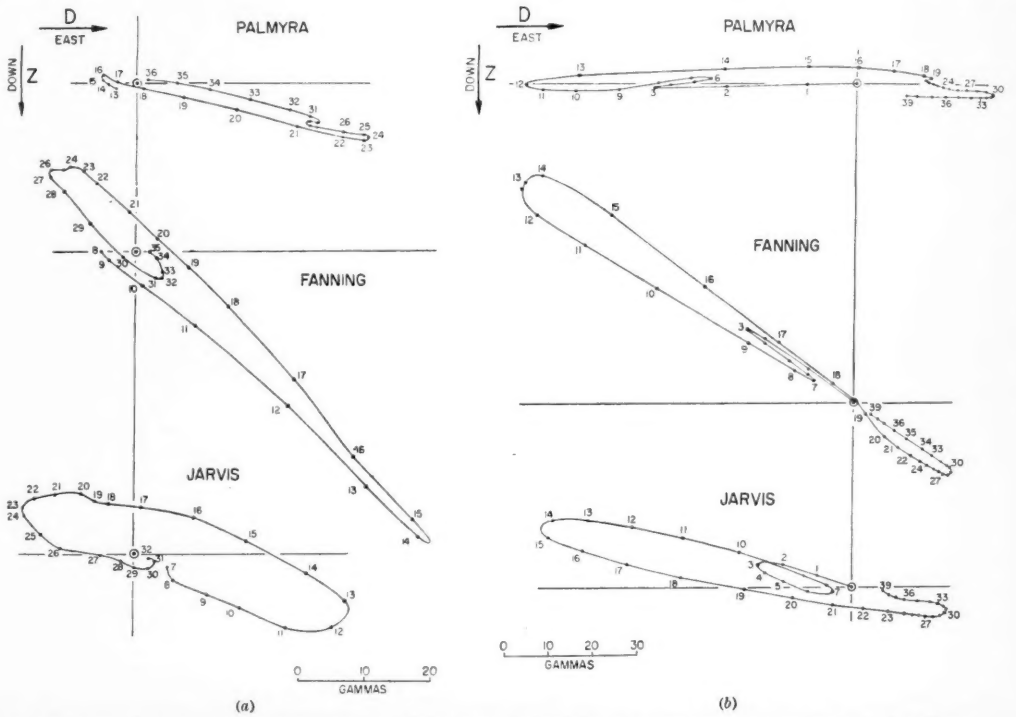

Fig. 3. Vector diagrams of the disturbance in the vertical plane perpendicular to the magnetic meridian for (*a*) the Christmas Island explosion of April 28, 1958; (*b*) the Johnston Island explosion of August 1, 1958. The small figures indicate the time in minutes after the event

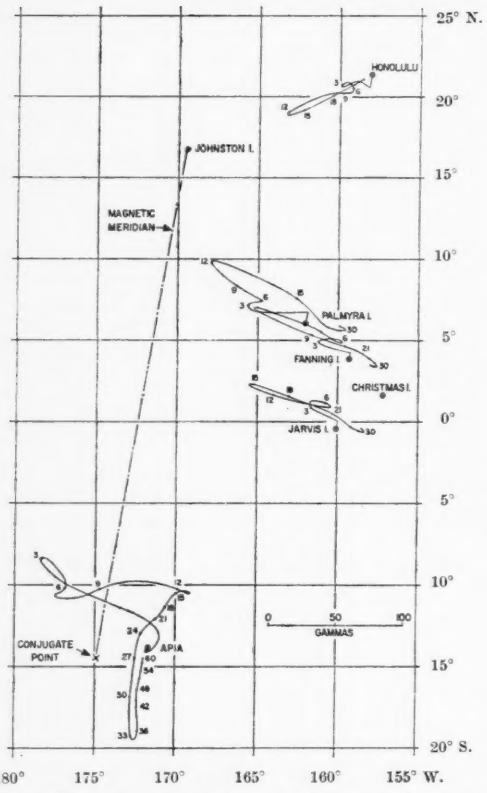

Fig. 4. Vector diagrams of the disturbance in the horizontal plane for the Johnston Island explosion of August 1, 1958. The small figures indicate the time in minutes after the event

explanation of the magnetic phenomena is to be expected; it is probable that several distinctly separate mechanisms are involved.

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CHEMISTRY

Carrier Gas and Sensitivity in Gas Chromatography

A recent article[1] takes issue with the "popular belief that the use of hydrogen or helium as the carrier gas in gas chromatography gives the highest sensitivity with a thermal conductivity detector, because the difference in thermal conductivity between organic vapours and hydrogen or helium is greater than for any other carrier gas". The article goes on to show that, for methane and ethane at least, the sensitivities are considerably higher with carrier gases that have a lower thermal conductivity.

The communication by Dr. Ray, however, treats the special case where the bridge current of the detector is held constant. In practice, not the bridge current, but the filament temperature is held constant. Under these conditions, helium is nearly ten times as sensitive as argon.

A standard C_4 hydrocarbon mixture was analysed on the same gas chromatographic column under the same condition with both helium and argon as carrier gases, while holding the bridge current constant at 150 m.amp. Values of the sensitivity parameter[2] (S-values) were calculated for the entire mixture; the S-value for argon was 252, for helium 300. *Ad hoc* experiments show that the filament temperature will be the same with helium as a carrier gas, operating with a bridge current of 350 m.amp., as with nitrogen or carbon dioxide as carrier gas with a bridge current of 150 m.amp.; argon is in the same range as nitrogen or carbon dioxide. The S-value for C_4 hydrocarbons in helium, with a bridge current of 350 m.amp., is approximately 3,000. In argon, a bridge current of this magnitude would cause the filament to burn out. The S-values obtained at the same filament temperature closely check the differences that would be expected for argon and helium based on the differences of their thermal conductivities and the thermal conductivities of hydrocarbon vapours; helium is 3,480, argon 398, and n-butane 322.

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[1] Ray, N. H., *Nature*, **182**, 1663 (1958).
[2] Dimbat, M., Porter, P. E., and Stross, F. H., *Anal. Chem.*, **28**, 290 (1956).

While it is true that a higher sensitivity can be obtained by using a higher bridge current, it is not usually possible to do this with commercial gas chromatography instruments, because manufacturers wisely limit the supply voltage to a level at which the katharometer filaments do not fuse in air or nitrogen. Even with home-made instruments the bridge supply voltage may be a limiting factor, since to maintain the same filament temperature in helium as in argon the voltage must be increased nearly three times.

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Measurement of Intergranular Diffusion in a Silicate System: Iron in Forsterite

Many geochemists and petrologists[1] concerned with the role of solid state diffusion in material transfer in silicate systems have noted the possibility that grain boundaries and dislocations might act as avenues for relatively rapid movement of the diffusing ions. Studies on metal systems are usually cited as evidence for this phenomenon. We wish to report some preliminary measurements on a silicate system where grain boundary diffusion seems to predominate in diffusive transfer.

The system used for the study was polycrystalline forsterite (magnesium orthosilicate) with ferrous ion as the diffusing material. Pellets were prepared

from stoichiometric mixtures of the pure oxides by compression at 15,000 lb./sq. in. and sintering at approximately 1,600° C. The samples were broken up and the operations were repeated four times to assure homogeneity. Radioactive iron-55 in a ferric chloride carrier was used as tracer, being applied as a spot in the centre of the forsterite disk. This was baked briefly at 1,000° C. to form ferric oxide, and then reduced at 900° C. in a controlled atmosphere of carbon dioxide and carbon monoxide adjusted to produce fayalite[2] (ferrous orthosilicate). After microscopic examination to detect imperfections and non-adherence, the sample was counted with an end-window Geiger counter under conditions such that the counting geometry could be reproduced exactly. The surface-decrease technique was used. The application of this method to the diffusion of iron-55 in oxides has been described in detail by Himmel, Mehl and Birchenall[3] and by Carter and Richardson[4], and similar methods were applied here. The diffusion annealing was carried out in the range 1,000°–1,200° C. in the controlled atmosphere furnace. Exploratory sections were taken in a few samples after diffusion by careful removal of active layers by grinding in a holder, and residual activity and thickness were measured after the removal of each layer. A few samples were ground at an angle, and autoradiographs were taken with Eastman 'No-screen' X-ray film.

Results for the diffusion coefficient as a function of temperature are plotted in Fig. 1. The straight line calculated according to the least-squares method corresponds to the equation:

$$D = 4{\cdot}17 \times 10^{-6} \exp(-38{\cdot}8\ \text{kcal.}/RT)\ \text{cm.}^2\ \text{sec.}^{-1}$$

The statistical limits for 95 per cent confidence for the activation energy are $\pm$ 3·6 kcal.

The results for sectioning are given in Fig. 2, for one typical example, and are plotted as log activity against both penetration distance and the square of this distance. According to Fisher[5], theory would predict a straight line in the former case for grain boundary diffusion, and a straight line in the latter case for lattice diffusion. It will be noted that grain-boundary movement is indicated. In all cases, autoradiography confirmed this conclusion. Penetration was found to be non-uniform and concentrated on lines and spots which were rather poorly defined, presumably because of the relative long range of the X-radiation from iron-55.

Despite their importance in geological, ceramic and metallurgical systems, few determinations of diffusion in solid silicate systems have been made. Most notable have been the measurements of Lindner[6]. His work indicates energies of activation for such systems of 47 kcal. or greater. The value of 38 kcal. found for the present system may be indicative of the greater ease of material transfer through grain boundaries. The picture of such interfaces as regions of ionic misfit with consequent concentration of lattice vacancies and dislocations makes the easier motion of solute ions through such sites readily understandable.

In most solid systems boundary diffusion is considered to play but a minor part in material transfer in comparison with lattice diffusion at temperatures above the Tammann temperature (approximately 0·5 T_m, where T_m is the melting point in degrees K.) because of the small area of the boundaries compared with the aggregate crystal area. The temperatures of

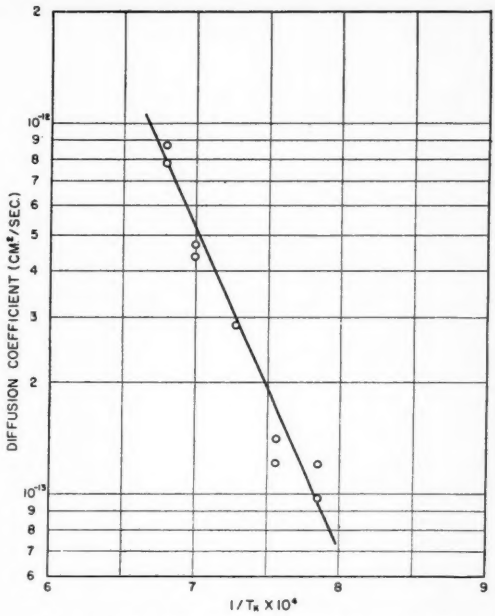

Fig. 1. Diffusion coefficient as a function of temperature

the measurements of this study are in this range. However, in orthosilicates we have a close-packed array of ions which may be considered to offer a singularly unfavourable condition for lattice diffusion and prove an exception to the above rule. In such a system, boundary diffusion might be expected to be greater than lattice diffusion, and measurements do seem to give a relatively unambiguous indication that such boundary diffusion can play a part in transfer in a silicate system.

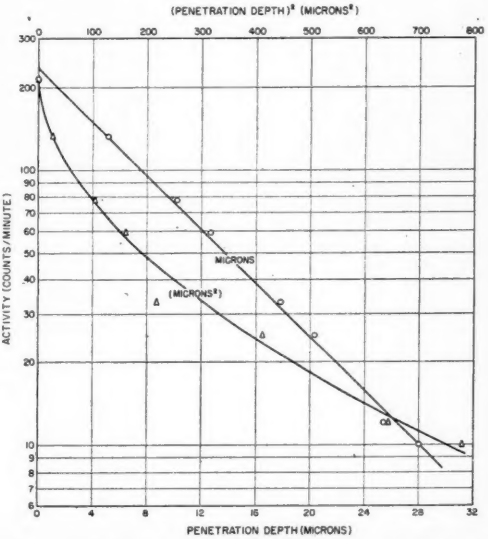

Fig. 2. Variation of activity with the distance and with the square of the distance, in a sectioned sample after diffusion anneal

It is of interest to calculate the distance of appreciable material transfer that would be possible through this intergranular pathway in geological periods of time—say, 10^6 years. By using the mean displacement equation, $X = (Dt)^{\frac{1}{2}}$, giving the relationship between the diffusion coefficient D, the time t, and the distance of transfer of the average concentration of diffusing material X, we can obtain an approximation of this last. In the range of 1,000°–1,200° C. one finds that a displacement of only 5–17 cm. is to be anticipated.

In considerations of petrographic metasomatic processes, particularly those involved in 'the great granite controversy', much argument has centred on the possible mechanisms of transfer of large quantities of matter, sometimes through great distances[7]. One group has sought to account for such transfer by solid state diffusion, and particularly by the intergranular pathway for such diffusion. Within the limitations of the conditions and the system studied, the above results would tend to support those who discount the role of diffusion in long-distance mass transfer, even through the supposedly easy route of the grain boundary.

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Influence of Gold in a Mercury Electrode on Certain Electrode Processes

It is usual to study electrode processes using hanging-mercury microelectrodes. Some authors prepare these electrodes by hanging a small mercury drop on a gold wire or a gold-plated platinum wire[1,2], deliberately neglecting the presence of the gold for its electropositive potential. Such an electrode is however an amalgam electrode, and, as we have shown[3], gold can influence the electrode processes of those metals which combine with it to form intermediate compounds.

The actual concentration of gold in different parts of the electrode is variable and dependent upon time, partly due to continuous diffusion of the gold. However, adopting certain approximations, it is possible to evaluate it. For a mercury drop with a radius of 0·05 cm. on a gold wire with a surface area of 0·1 mm.^{2} the concentrations of gold in the mercury 20, 60, 200 sec. after the drop was first suspended on the wire are, respectively, 0·001, 0·05 and 0·01 per cent. To ascertain whether those concentrations are sufficient to form intermetallic compounds on the surface of the electrode we have prepared 0·001, 0·01 and 0·1 per cent gold amalgams for use with the

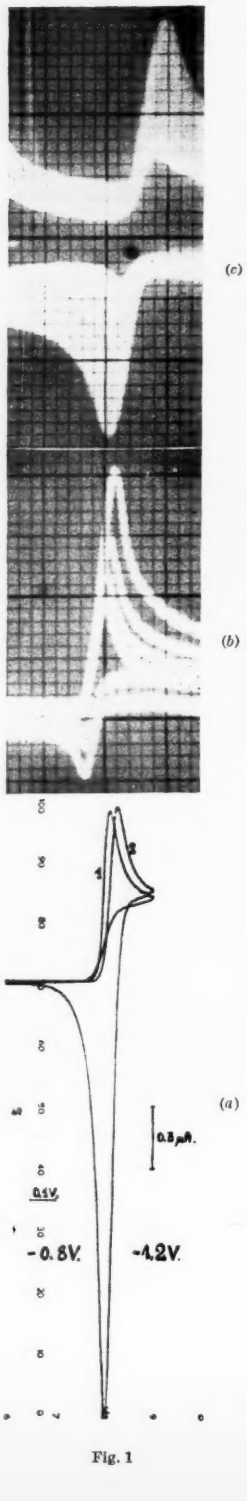

Fig. 1

electrodes previously described[4]. With these electrodes, 5×10^{-4} *N* solutions of lead, thallium, cadmium and zinc ions were investigated, by means of cyclic polarization of the electrode, using different rates of voltage sweep and recording the corresponding voltammetric and oscillographic curves.

It was confirmed that the presence of gold in the electrode greatly influences the electrode processes of zinc. Fig. 1*a* shows the cyclic voltammetric curves for zinc on the 0·1 per cent gold amalgam electrode (curve 1) and on a mercury electrode (curve 2). They differ significantly in both cathodizing and in anodizing.

On gold amalgam the cathodic process is shifted about 20 mV. towards more positive potentials compared with a pure mercury electrode. The differences in the anodic processes are even more pronounced. Zinc is not oxidized at the reversible potential (about −1·0 V.), which is caused by the formation in mercury of a compound, AuZn, that can be oxidized at more positive potentials. A similar effect can be observed even with less concentrated amalgams. Fig. 1*c* shows the oscillopolarographic curves for zinc at a frequency of 4 c./s. when the exposure was 30 sec. and the concentration of gold in the amalgam is 0·01 per cent. The more pronounced effect is seen in Fig. 1*b*, where the voltage sweep was 0·3 V./sec. It is evident that both the reduction current for zinc ions, and the oxidation current of zinc from the amalgam, decrease with time when the compound AuZn is formed. This does not occur with the pure mercury electrode. The influence of gold can be neglected only when its concentration in the amalgam is less than 0·001 per cent.

Similar effects were observed for cadmium, although the intermetallic compound AuCd is not so stable as AuZn. Its formation can be observed when the concentration of gold exceeds 0·01 per cent. No influence of gold on the electrode processes of lead and thallium was found.

Those experiments show clearly that the use of gold or gold-plated wires for suspending the mercury drop can give erratic results if the formation of intermetallic compounds is neglected.

On the other hand, our technique for preparing hanging-mercury drop electrodes does not suffer from this difficulty.

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Carbonate Minerals in Hydrated Portland Cement

Although the physical effects of the carbonation of hydrated cements and mortars have been studied[1–3], the way in which the carbon dioxide is held has not yet been clearly established. Most workers have assumed that it exists in the form of calcite; but in work at this Division[3,4] and elsewhere[5] the quantity of calcite detected by X-ray diffraction and differential thermal methods is always much less than the amount of carbon dioxide recoverable from the samples. We have investigated this problem in some detail using samples of mortar and carbonated calcium silicate hydrate.

From a study of the X-ray diffraction patterns of the materials before and after carbonation, using a Guinier-type focusing camera of high dispersion, we have concluded that the carbon dioxide is chemically bound as calcium carbonate largely in the form of poorly crystallized vaterite, aragonite and calcite. These minerals have three-dimensional lattices; this does not support the suggestion of Gaze and Robertson[5], based on indirect evidence, that the carbon dioxide in carbonated tobermorite could be present as two-dimensional calcite. Our results also show that well-crystallized calcite is present in small quantities, but that its amount is not greatly increased by carbonation. In the past, X-ray analyses have determined the amount of this well-crystallized calcite, rather than the amount of the less easily detected poorly crystalline forms now proved to be present, and so have failed to account for all the carbon dioxide found in carbonated mortars.

Other workers[1–3] have shown, and we confirm, that the calcium carbonate minerals have formed both from the decomposition of hydrated cement minerals and from calcium hydroxide produced during the hydration of $3CaO.SiO_2$ (alite) to $xCaO.SiO_2.yH_2O$ in the setting of the cement. As a result they are intimately associated with a siliceous residue with which they readily react on heating. In differential thermal analysis the decomposition of the poorly crystallized calcite produces only a slight endothermic effect (at about 700° C.) and its reaction with the siliceous residue to form larnite (β-$2CaO.SiO_2$) is not exothermic. Therefore this method, too, gives little or no indication of carbon dioxide minerals other than well-crystallized calcite (strong endothermic effect at about 850° C.) in carbonated mortars.

Since carbonation of mortars requires the presence of moisture[1–3], we suggest that the process takes place through the action of carbonic acid on cement minerals yielding poorly crystallized vaterite, aragonite and calcite in the following manner: Cement minerals → siliceous residue + calcium hydroxide → vaterite + aragonite + poorly crystallized calcite → well-crystallized calcite.

A more detailed account of the investigation will be published elsewhere.

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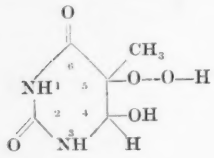
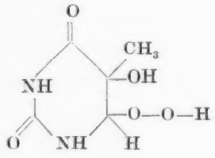
IRRADIATION CHEMISTRY

Structure of Thymine Hydroperoxide produced by X-Irradiation

Weiss *et al.*[1] have shown that X-irradiation of aerated aqueous solutions of nucleic acids, pyrimidine nucleotides or pyrimidine bases gives rise to hydroperoxides. In the case of thymine, they proposed the following possible structures:

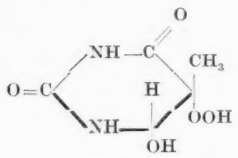


(I)

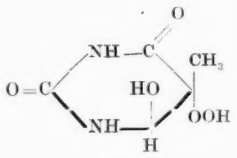


(II)

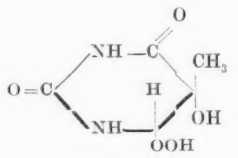
which are in agreement with previous preliminary results from this laboratory[2]. As the hydroperoxide produced by X-irradiation of thymine was sufficiently stable to permit isolation, the synthesis of compounds corresponding to formulæ I and II was attempted in order to compare them with the products isolated from X-irradiated thymine solutions. Each of these two compounds can presumably exist in two forms, *cis* and *trans*:



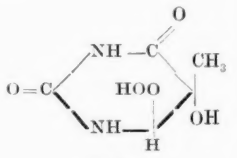
(I *cis*)



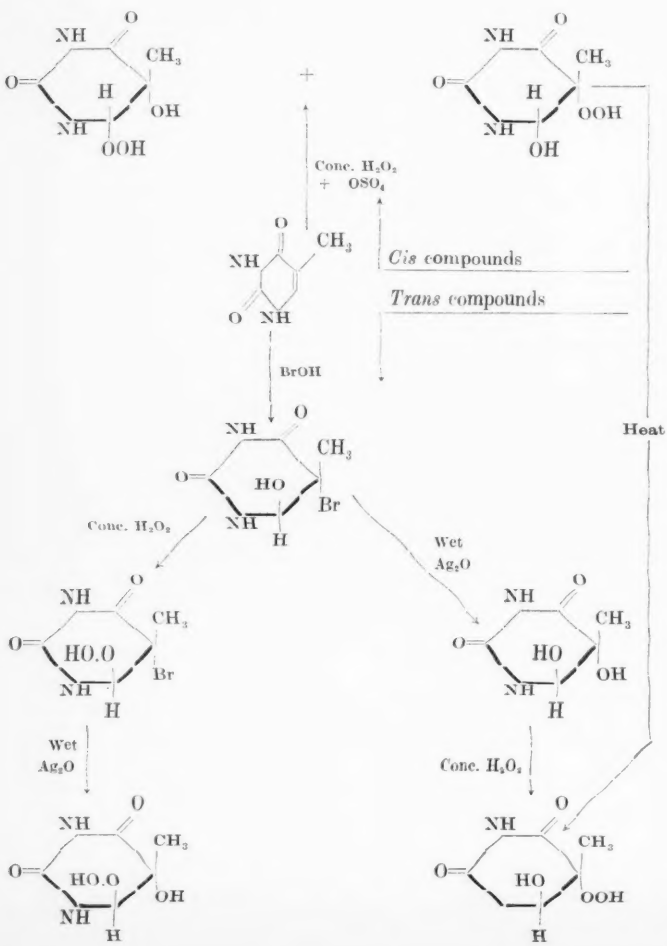
(I *trans*)



(II *cis*)



(II *trans*)



The *trans* compounds were separately synthesized from a common starting material: *trans*-4-hydroxy-5-bromothymine, prepared by Jones's method[3]. Compound II *trans* was prepared by treatment of the starting material with hydrogen peroxide in dilute hydrochloric acid to give 4-hydroperoxy-5-bromothymine. Bromine was eliminated by shaking with silver oxide and centrifuging. The product was freed of the last traces of silver oxide by extraction with a chloroformic solution of dithizone. After lyophilization, the residue could be crystallized, with some difficulty, from acetone–petroleum ether. To give compound I *trans*, the starting material was transformed into 4,5-dihydroxythymine[4], which was then treated with hydrogen peroxide. After elimination of excess hydrogen peroxide by repeated lyophilizations, the residue could be crystallized from acetone–benzene. Compounds I *trans*, II *trans* and 4-hydroperoxy-5-bromothymine can easily be separated by paper chromatography, using *n*-propanol/1 *N* hydrochloric acid as a solvent (Table 1).

The treatment of thymine itself with hydrogen peroxide in the presence of catalytic amounts of osmium tetraoxide gives a mixture of two peroxidic compounds, which can be resolved by paper chromatography, giving spots with R_F 0·51 and 0·62 respectively. Since these two compounds do not behave on paper chromatograms like the *trans* hydroperoxides previously described, they probably are the *cis*

Table 1. Paper Chromatography of Hydroperoxidic Derivatives of Thymine

Paper, Whatman No. 1; solvent, *n*-propanol/1 *N* hydrochloric acid (85/15, v/v); temperature during run, 2° C.

Compound		R_F
4-Hydroxy-5-hydroperoxythymine	*cis**	0·51
4-Hydroxy-5-hydroperoxythymine	*trans**	0·33
4-Hydroperoxy-5-hydroxythymine	*cis**	0·62
4-Hydroperoxy-5-hydroxythymine	*trans**	0·43
4-Hydroperoxy-5-bromothymine	*trans**	0·83
4-Hydrogen peroxide*		0·68
Thymine†		0·55

* Detected by spraying a 4 per cent alcoholic solution of potassium iodide.

† Detected in ultra-violet light.

compounds. On heating a solution of the mixture, the product with R_F 0·51 is transformed into a product giving a spot with R_F 0·33, while the product with R_F 0·62 remains unchanged. Accordingly, it may be suggested that the product with $R_F = 0{\cdot}51$ corresponds to formula II *cis*, as indicated in Table 1. These syntheses and the relationships between the compounds are summarized in the scheme on p. 58.

All the compounds can be reduced at the dropping mercury electrode in 0·1 *M* potassium sulphate at the same potential near 0 volt, against the saturated calomel electrode at 25° C. They behave similarly on 'Dowex 50–H⁺' columns.

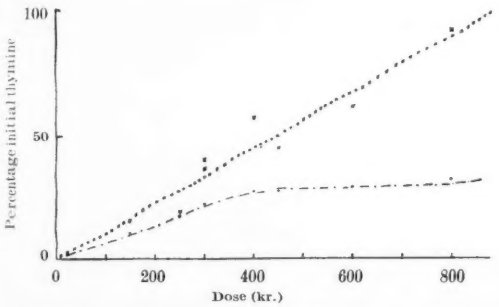


Fig. 1. Destruction of thymine (— × — × —) and total production of hydroperoxide (– · – · –) by X-irradiation of a 10^{-3} *M* thymine solution by X-rays of 40 kV., filtered through 0·04 mm. aluminium; dose, 25 kr., in air

In Fig. 1 are shown the curves relating dose to thymine destruction and total hydroperoxide production, during X-irradiation in air. A 10^{-3}-*M* solution of thymine, after irradiation with 400 kr., contained $2{\cdot}1 \times 10^{-5}$ *M* hydrogen peroxide and $1{\cdot}9 \times 10^{-4}$ *M* hydroperoxide. After repeated lyophilizations, the residue was put on a 'Dowex 50-X 8' column, 1 cm. × 50 cm., in 0·1 *N* hydrochloric acid. The eluate was collected in 4-ml. fractions. Hydroperoxidic products, detected by the iodide reagent, appeared in fractions 5–11, and unchanged thymine in fractions 16–21. After paper chromatography and spraying with iodide reagent, material contained in fractions 5–11 gave a strong spot at the level of the spot given by compound I *cis* and a faint one at the level of the spot given by compound I *trans*. Control chromatographs of various mixtures of synthetic peroxides and peroxides produced by X-irradiation demonstrated that the latter cannot be distinguished from the former with corresponding R_F's. Therefore, it may be suggested that X-irradiation of thymine in aqueous aerated solutions actually produces hydroperoxides I *trans* and I *cis*.

We wish to thank Dr. R. Laterjet for his interest throughout this work.

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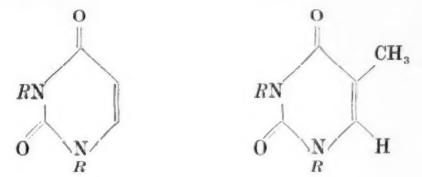
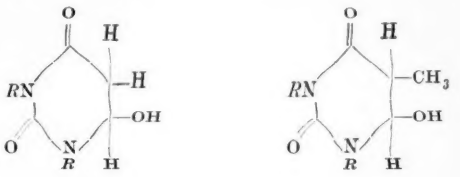
Ultra-violet Irradiation of 1,3-Dimethylthymine

When 5,6-unsubstituted pyrimidines (I) such as uracil, uridine and 1,3-dimethyluracil are irradiated with ultra-violet light, the absorption spectra gradually decrease[1] with a simultaneous increase in end absorption. These spectra can be reversed to the original by acid, alkali or heat[1].



However, compounds substituted in the 5-position (II), such as thymine, thymidine and 1,3-dimethylthymine, do not show reversal under similar conditions. Most investigators have suggested that this difference may be due to totally different photochemical reaction mechanisms in the two cases[2].

Upon close examination of these two groups of compounds it appears that they probably have the same electronic distribution, because the ketonic form as shown above is probably the common and predominant configuration in both[3]. Since the interaction with ultra-violet light is related to the electronic state of a compound, it is not unreasonable to assume that the initial step is similar for both groups of compounds.

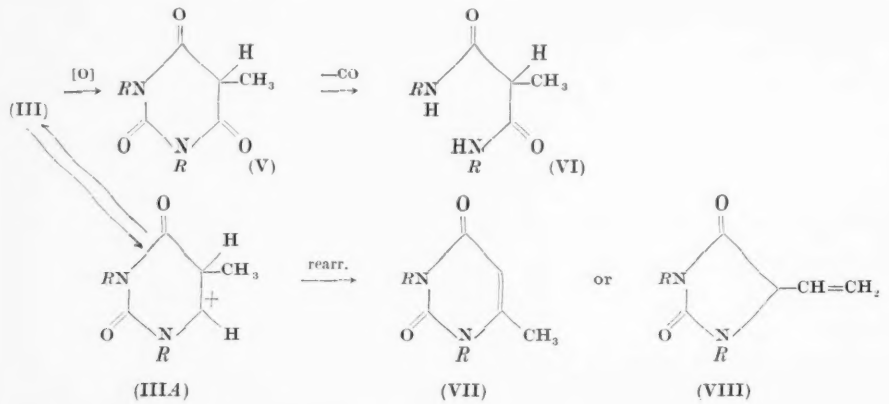


If the above assumption is true, then 6-hydroxyhydrothymines (III) would be expected as the first products, because 6-hydroxyhydrouracils (IV) have been shown to be the first products of the irradiation of uracils (I)[1]. The reconstitution reactions of uracils were found to be dehydrations[1]. For thymines, such dehydration would involve the much more reactive III°-H rather than the II°-H as in the uracils. There-

fore, the dehydration of III is probably much faster than the photo-addition of water to II. This reverse

$$\text{II} \xrightarrow{h\nu,\ \text{HOH}} \text{III} \qquad \text{III} \xrightarrow{-\text{HOH}} \text{II}$$

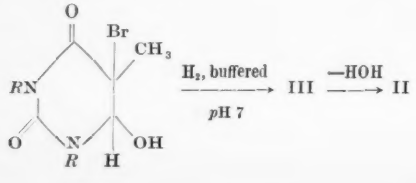
reaction would prevent the detection of III during and after irradiation, and would not be associated with a decrease in the absorption spectrum of II. Actually, however, this spectrum decreased with irradiation, and probably was due to further reactions of III to form irreversible compounds. For such reactions there are two possible routes:



If carbonium ions (IIIA) were formed from III, then through rearrangement either VII or VIII or both could be the products. If 'oxidation' were to occur, according to the route already established for uracils, then V would be the intermediate. Upon decarboxylation N,N′-dimethylmethylmalonamide (VI) would be the product[4].

In order to support experimentally the above arguments, the following two points would have to be demonstrated: first, the intermediate of hydration (III) must be shown to be much more unstable than that of 6-hydroxyhydrouracils (IV); second, one of the irradiation products via the intermediate (III) would have to be isolated.

We have used 1,3-dimethylthymine as a model compound. First, 5-bromo-6-hydroxy-1,3-dimethylhydrothymine (IX) was prepared and was reduced in a manner identical with that used for the preparation of 6-hydroxy-1,3-dimethylhydrouracil[1,5]. Examination of the ultra-violet spectrum of the reaction solution suggested that only 1,3-dimethylthymine was obtained as the product with little indication of the existence of 6-hydroxy derivatives.



(IX)

Upon hydrogenolysis of the 5-bromo-6-hydroxy derivatives of uracils, however, the following yields of 6-hydroxy derivatives were obtained in solution: from uridine, 40 per cent; from 1,3-dimethyluracil, 80 per cent; and from uracil, 30 per cent. Therefore, this suggested that III has a much greater tendency for dehydration than uracils have. Second, 1,3-dimethylthymine was irradiated in aqueous solution until a flat ultra-violet spectrum was obtained. The irradiation products were then separated and purified. One of the products has been identified as N,N′-dimethylmethylmalonamide (VI, m.p. 157–158° C. Found: C, 50·08; H, 8·39; N, 19·42. Synthetic VI, m.p. 157–158° C., mixed m.p. with irradiation product 157–158° C.; Found: C, 50·02; H, 8·25; N, 19·65. The infra-red spectra of synthetic VI and the irradiation product were identical.) On the basis of this evidence we would like to suggest that 1,4-addition of water to the thymine derivatives is the first step in the ultra-violet irradiation effect.

By examination of the quantum yields of the irradiation of thymine both in light and heavy water, Shugar has drawn the conclusion that the uptake of a water molecule is not involved[6]. From our findings it would appear that the measurements he made were actually of the subsequent slower steps and probably not for the initial fast reversible step.

Therefore, from the above findings, we have demonstrated that uracil and cytosine derivatives react similarly toward ultra-violet irradiation. This emphasized the fact that for the photochemical pathway of ultra-violet irradiation effects, the differences in electronic distributions of compounds are of more importance than the differences in their structures. They further suggest that the hydration product (III) may be of importance in photoreactivation reactions. Although the first irradiation products of uracils exhibit the phenomenon of reversibility, the irradiated uracils are stable under the customary photoreactivation conditions. Under biological conditions, however, the unstable initial thymine products (III) might be stabilized by secondary linkages, for example, H-bonds, in the nucleic acids. The H-bonds so formed could be broken by the usual photoreactivation conditions. Thus, thymines might be reconstituted and again show the biological activity of the original bases.

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Degradation of Thiotaurine by Ionizing Radiations

THE degradation of sulphur-containing compounds by ionizing radiation has been extensively studied[1–3] in view of the protective action of those compounds against radiation damage in animals. Recently, thiotaurine (aminoethylthiosulphonate) has become available for chemical and biological investigation[4,5]. Since thiotaurine was discovered as a metabolic product of cystine[6] and cystamine[7] in the rat, and since it is chemically related to cysteamine, it seemed of interest to study its reactivity towards irradiation with X-rays and γ-rays.

30 μmoles of pure thiotaurine dissolved in 3 ml. of water were placed in a glass vessel 2·5 cm. diameter. The solution was irradiated for a suitable length of time with a Philips 50 kV. X-ray source having a beryllium window. The shorter distance from the window to the centre of the solution was 1 cm. The intensity of irradiation was determined with a ferrous sulphate dosimeter[8]. 0·15 ml. of the solution was withdrawn for analysis at intervals.

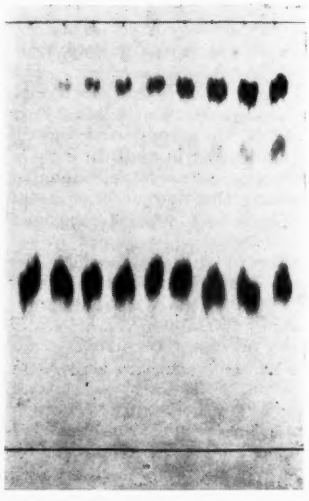

Fig. 1. Progressive chromatogram of the irradiated solution of thiotaurine with X-rays. Dose (r.), left to right, 0, 12,000, 36,000, 60,000, 84,000, 120,000, 240,000, 360,000, 480,000. Descending chromatogram in collidine–lutidine, developed with ninhydrin. 0·5 μmole of initial thiotaurine spotted at the starting line. *A*, hypotaurine; *B*, taurine; *C*, thiotaurine

As soon as irradiation started it became apparent that some reaction was taking place: the solution became more and more turbid. The degree of turbidity increased with the time of irradiation. The unirradiated control remained clear for a long time.

The material which caused turbidity was identified as colloidal sulphur by sedimentation in a 'Spinco' model *L* preparative ultracentrifuge at 125,000*g*, followed by conversion of the washed residue to thiocyanate by the procedure of Bartlett and Skoog[9].

Some of the compounds produced by the radiochemical degradation of thiotaurine have been detected by paper chromatography. At intervals a sample of the irradiated solution was spotted on a Whatman No. 4 filter paper and the chromatogram was run in collidine/lutidine/water (1:1:1 v/v) and developed with ninhydrin. Apart from a residue of unchanged thiotaurine, two main compounds reacting with ninhydrin appeared on the chromatogram. These have been identified, by careful comparison with the synthetic products and by specific reactions[6], as hypotaurine and taurine. Hypotaurine is the first degradation product to appear; its spot appears after a dose of 12,000 r. Taurine appears later and only in small amounts.

The production of hypotaurine and colloidal sulphur is consistent with the following overall reaction:

$$NH_2—CH_2—CH_2—SO_2SH \rightarrow NH_2—CH_2—CH_2—SO_2H + S$$

which represents the reversal of the reaction used for the synthesis of thiotaurine from hypotaurine and sulphur[4].

Essentially the same results have been obtained by irradiating a solution of thiotaurine with a comparable dose of γ-rays from a radium source immersed in the solution. The irradiation of a solution of thiotaurine buffered with phosphate *p*H 7·4 also gave identical results.

It is of interest that cystamine, one of the best known protective agents against radiation damage, under the same conditions and using the same procedure to detect degradation products, gave only a faint trace of taurine even with the higher doses of X-rays. In the light of these results the comparative effect of cystamine and thiotaurine in the radioprotection of animals is being studied.

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GEOLOGY

The Geological Time-Scale

Recently Dr. K. I. Mayne, Dr. R. St. J. Lambert and D. York[1] proposed an extended geological time-scale which would place the middle of the Upper Cambrian at about 650 million years ago compared with 450 million years of the Holmes scale[2]. Their scale is based primarily on the ages they obtained by the potassium–argon method on biotite from several British granites; however, they cite many other age measurements for secondary support. It is the purpose of this communication to point out that most of the cases cited are either incorrect or not definitive to the argument. In addition, both they[1,3] and Prof. C. F. Davidson[3] refer at some length to our as yet unpublished isotopic study of the Swedish kolm. These comments contain errors of fact and interpretation which will be clarified by the full report which will appear elsewhere; but in view of the widespread misconception concerning this interesting material some discussion appears needed at this time. The British granites referred to above are being remeasured in this laboratory and results will be reported later.

First, concerning the alleged support of the extended time-scale:

(1) Mayne *et al.*[1] cite pitchblende measurements in the Upper Triassic Chinle formation of the Colorado Plateau by Miller and Kulp as indicating an age of about 210 million years. The published abstract[4] of the oral paper to which they refer does not imply this conclusion, and in the full published paper[5] Miller and Kulp discuss the problems involved and conclude that "The apparent (i.e., isotopic) ages bear no necessary relation to the actual time of deposition".

(2) Mayne *et al.*[1] incorrectly list a result of 360 million years from the Georgia Piedmont as being Permo-Carboniferous in age and refer to a paper by Kulp and Long. In the published abstract[6] the only reference to this area states: "In the Southeastern Piedmont of Georgia there is evidence for a younger event occurring around 260 m.y. ago", but there was no attempt to make a stratigraphic assignment. In the oral presentation it was noted that there might be a correlation between this 260 million year metamorphic event and coarse sedimentation in the southernmost part of the Appalachian geosyncline during Carboniferous time; but it was emphasized that no direct stratigraphic correlation with the metamorphic rocks of the Georgia Piedmont is possible. A full report on the age work in the south-eastern Piedmont will appear elsewhere[7] shortly.

(3) The Beryl Mountain pegmatite is actually intruded into the pre-Silurian Ammonoosuc volcanics according to Kruger[8], and not the lower Devonian Littleton formation. Even if the pegmatite were intruded at the time of metamorphism of the Littleton formation as assumed by Damon and Kulp[9], there is no stratigraphic reason for suggesting a Carboniferous age as is done by Mayne *et al.*

(4) The samples of feldspar (Dubuque formation and Mynydd Mawr granite) and sylvite give only minimum ages. The retention of argon in these materials has not been sufficiently well defined to use them for quantitative age determination. Mayne *et al.*[3] in their latest communication agree that little importance should be attached to these dates.

(5) The Boisdale Hills granite, according to the latest geological information (Hurley, personal communication), is not intimately related to the fossil sequence; but presumably the same or a similar granite less than one mile away intrudes a sedimentary sequence dated as Middle Cambrian to Lower Ordovician. The age of 490 million years is therefore much more likely to be a minimum for Lower Ordovician rather than being post-Lower Devonian as Mayne *et al.*[1] state.

(6) The post-Lower Devonian intrusives in both Nova Scotia and Maine as measured by the Massachusetts Institute of Technology group[10] give ages which group at about 365 million years, not 400 million years as used by Mayne *et al.*[1].

(7) The errors on the rubidium–strontium ages on bentonites are too large to allow the ages to be definitive. The Adams *et al.*[11] report was only preliminary, and further work needs to be done before the apparent ages on bentonites can be properly interpreted.

In their reply to Prof. Davidson, Mayne *et al.*[3] correctly reject those points cited by Prof. Davidson as evidence against their extended scale where "either the stratigraphy of the sample or their measured age is not free from unwarranted assumptions". In the above discussion, these same criteria have been used to evaluate the dates and localities used in the first report by Mayne *et al.*[1] as support for their expanded time-scale. The Russian measurements on mica from pebbles in Lower Cambrian rocks, as reported by Davidson[3], cannot be dismissed so easily as Mayne *et al.*[3] have done. If the measurements have been properly made and the minerals have not been altered since, the results are significant. The two pebbles which give isotopic ages of 566 and 763 million years could represent rocks of different real ages. In this case, the younger age would set an upper limit on that part of the Lower Cambrian. It is concluded that the evidence for the extended time-scale lies almost entirely with the measurements made by Mayne *et al.*[1] on the Shap, Cairnsmore and Land's End granites.

The extensive consideration which Mayne *et al.*[1] and Davidson[3] gave the kolm in the Upper Cambrian Swedish black shale is illustrative of the importance of the age of this formation in establishing a time-scale. More than twenty kolm samples from this formation collected over a wide geographical area have been analysed in this laboratory. The isotopic uranium–lead ages are grossly discordant and vary from sample to sample[12]. The detailed interpretation and discussion of these apparent ages are being prepared for publication in another journal[13]. From these measurements it has been concluded that the discordance among the isotopic ages is caused by a combination of bulk lead loss and additional preferential loss of lead-206 due to migration of an intermediate member in the uranium-238 decay chain during the history of the mineral. On this basis, an analysis of the data indicates a minimum age for this formation of about 500 million years. The complexity of the leaching processes occurring is such that a maximum age cannot be assigned solely on the basis of the isotopic data. Mayne *et al.*[1] attribute to us the statement, "They believe the true age to be no greater than 550 m.y." This does not correspond to our opinion, and the reference they cite does not contain this statement. The evidence points to the minimum age as being nearly correct, but there is no unique solution of the data.

Davidson's[3] discussion of the meaning of the kolm ages is erroneous. He mentions that the formation contains old radiogenic lead. Our data strongly

indicate that the lead incorporated in the black shale at the time of its deposition was normal in its isotopic composition. His hypothesis that uranium has been continuously introduced into the kolm by percolating ground water is not supported by the observed distribution of uranium in the kolm. Further, it should be pointed out that the effect on the isotopic ages due to introduction of uranium is indistinguishable from that due to loss of lead. Therefore, even if this hypothesis were adopted it would not cause any revision in the interpretation that the minimum age of the kolm is about 500 million years. Davidson's deduction that the formation is necessarily younger than 650 million years since this is the lowest lead-207–lead-206 age is not valid. The meaning of this age is directly dependent on the nature of the chemical alteration that occurred.

The current investigations in a number of laboratories on the age of stratigraphically well-defined rocks will permit a much closer definition of the geological time-scale in the near future. The extended scale proposed by Mayne *et al.*[1] is based on limited data and is not supported by measurements other than their own.

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Palæomagnetism and Rotation of Newfoundland

Nairn, Frost and Light have recently reported[1] on the palæomagnetic results from Carboniferous and Pre-Cambrian rocks of Newfoundland. By comparing their Carboniferous results with results obtained by other workers[2] in the western United States they show that Newfoundland may have been rotated 20° anticlockwise since Carboniferous time.

I wish to report some results obtained from Carboniferous rocks of New Brunswick and the Gaspé Peninsula, which, with the results of Nairn *et al.*, show that no relative rotation between Newfoundland and these areas has occurred since Carboniferous times. Therefore, if the proposed rotation of Nairn *et al.* is correct, New Brunswick, the Gaspé Peninsula and Newfoundland must have rotated as a unit.

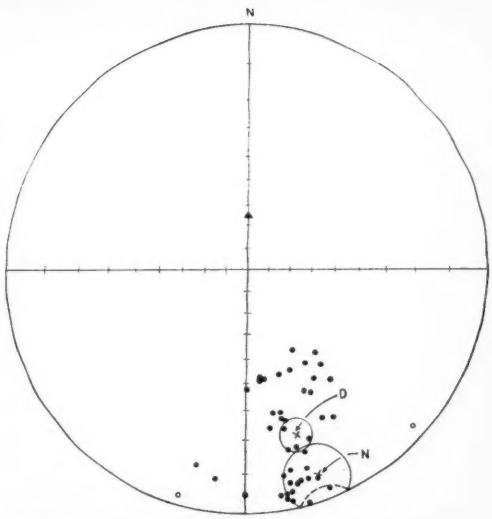

Fig. 1. Directions of magnetization measured in Carboniferous rocks of the Canadian Maritime Provinces. ●, Directions of magnetization of my samples, north pole on lower hemisphere; ○, directions of magnetization of my samples, north pole on upper hemisphere; $\bar{X} \leftarrow D$, mean direction of my samples (with circle of confidence at Fisher's 95 per cent level of probability); $\bar{X} \leftarrow N$, mean direction of samples of Nairn *et al.* (with circle of confidence at Fisher's 95 per cent level of probability); ▲, direction of magnetic field produced by a central axial dipole oriented along the Earth's present axis of rotation

In the summer of 1958 twenty-two samples of the Bonaventure formation (Upper Mississippian or Lower Pennsylvanian) were collected by me from the south shore of the Gaspé Peninsula, Province of Quebec, between Percé and Maguasha. Fourteen samples were also collected from the Kennebecasis formation of Mississippian age at localities about fifteen miles north-east of St. John, New Brunswick. Ten samples were collected by Dr. C. H. Stockwell in the autumn of 1955 from the Pennsylvanian Bathurst formation near Bathurst, New Brunswick. Two 1-in. cubes were cut from each of these samples and were measured on the astatic magnetometer of the Dominion Observatory, Ottawa. The mean direction of each sample has been plotted on a stereogram in Fig. 1. Since rocks were collected from an extensive area, their directions have been corrected to the geographical location 48° N. and 66° W. by assuming that the Earth's average magnetic field is a dipole. The mean direction of the results of Nairn *et al.* from the Codroy gypsum also has been corrected to 48° N. and 66° W. and plotted on Fig. 1.

By inspection one can see that there is no significant difference between the declinations of the Newfoundland samples and of those reported here. This surmise is confirmed by Fisher's statistical analysis which gives a mean direction, corrected to 48° N. and 66° W., of $D = 160{\cdot}5°$ and $I = +6{\cdot}0°$ with a circle of confidence of $8{\cdot}4°$ for the samples of Nairn *et al.*, and a mean direction of $D = 163{\cdot}5°$ and $I = +19{\cdot}5°$ with a circle of confidence of $5{\cdot}0°$ for my samples. Thus, there is no significant difference between the two directions, and there is no evidence for any relative rotation between Newfoundland and the mainland Maritime Provinces, since Carboniferous time.

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BIOCHEMISTRY

Kinetic Study of Dextransucrase based on the Langmuir Adsorption Isotherm

The action of the polysaccharide-synthesizing enzyme dextransucrase has been described previously in terms of *p*H [1] and the effect of various alternate receptors[2,3]. We have now examined the dependence of rate of reaction on the concentration of enzyme. The results are interpreted on the basis of adsorption kinetics[4], where the substrate (sucrose) and acceptor are adsorbed simultaneously on adjacent sites of the enzyme. This is followed by glucosyl transfer from sucrose to acceptor. No reaction occurs between bound sucrose and acceptor in solution, and there is no separate hydrolytic step prior to the transfer of the glucosyl group.

The kinetic studies were carried out by exposing sucrose solutions to varying amounts of crude enzyme solution at 25° C. and *p*H 5·2, and measuring the amount of fructose produced at a given time The enzyme was prepared as reported elsewhere[1]. Sucrose solution (0·2 ml. of a 0·01 *M* solution in 0·05 *M* acetate buffer *p*H 5·2) was incubated with 0·02–1·6 ml. of the enzyme solution (assaying 49 units/ml.) and buffered to make a final volume of 1·8 ml. After ½ hr. the reaction was quenched with 0·1 *M* sodium hydroxide and the reducing sugars determined colorimetrically[5,6]. A plot of rate against enzyme concentration is shown in Fig. 1.

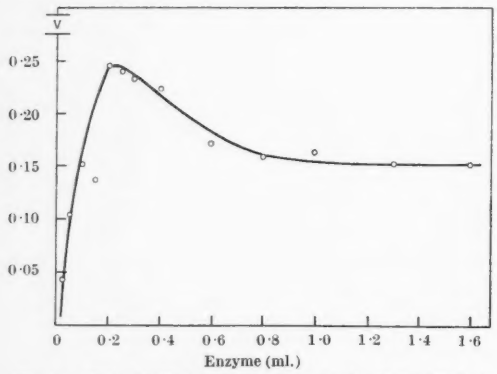

Fig. 1. Plot of initial velocity (mgm. fructose/1·8 ml./½ hr.) against enzyme concentration

The appearance of a maximum in such a plot is rare; however, it has been reported for the lactic dehydrogenase system[7]. Laidler and Socquet[4] have treated this case theoretically and have derived the following rate equation:

$$v = \frac{kK_1K_2[E]_0[S_1]_0[S_2]_0}{\{1+[E]_0(K_1+K_1')+K_1[S_1]_0+K_1'[S_2]_0\}\{1+[E]_0(K_2+K_2')+K_2'[S_1]_0+K_2[S_2]_0\}} \quad (1)$$

where k is the rate constant for the decomposition of the complex; S_1 and S_2 are the two substrates, in this case sucrose and acceptor; K_1 and K_2 are the corresponding equilibrium constants for the formation of the binary complex; K_1' and K_2' are the equilibrium constants for the cross adsorption of S_2 on site 1 and S_1 on site 2 respectively. It is seen that equation (1) predicts linearity of rate against enzyme or sucrose at low concentration, but an inverse relationship and hence a maximum at high concentration.

At high enzyme concentration, the substrates are spread out over a large number of enzyme sites. The observed decrease in rate is attributed to the decreased probability that adjacent sites will be occupied in these circumstances. The previously observed maximum in the rate against sucrose concentration[8] indicates that sucrose is cross-adsorbed on the acceptor sites (which may well be identical with the donor sites) and thus inhibits the reaction. Attempts to observe maxima in S_2 by adding alternate acceptor have been complicated by the presence of the natural acceptor. Thus far, only a roughly linear increase of rate with acceptor concentration has been observed.

If a reaction were occurring between bound substrate and unbound acceptor, no maximum would occur. Furthermore, it has been shown[4] that in cases where one substrate is solvent there is no maximum in the enzyme curve. Hence the possibility of a hydrolytic reaction with sucrose followed by a rate-determining combination with dextran is eliminated. The presence of the observed maxima thus fits only the case of simultaneous two-substrate adsorption.

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Agar Electrophoresis of Normal Soluble Proteins in Guinea Pig Liver

Hitherto, neither free electrophoresis[1] nor electrophoresis on filter paper of the soluble proteins in liver (ref. 2, and Smetana, R., and Kořínek, J., personal communication) has afforded satisfactory delimitation of a sufficient number of fractions. After obtaining a number of unsatisfactory results on filter paper, we turned our attention to electrophoresis on agar gel.

Healthy guinea pigs weighing between 300 and 900 gm. were lightly anæsthetized with ether before being perfused with normal saline. The liver was ground in a mortar with quartz sand. 1–3 ml. of a 0·7 per cent solution of sodium chloride (the amount depending on the size of the liver) was added and the whole stored in a refrigerator. 24 hr. later it was centrifuged at 6,000 r.m.p. for 2–3 hr.

Table 1

Fraction	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*
Average percentage value (*M*)	2·1	6·1	7·1	4·7	4·1	5·5	10·1	19·7	32·5	5·2	1·6	0·6	0·7
Standard deviation (σ)	±0·7	±1·8	±2·1	±1·4	±1·1	±1·6	±2·2	±5·2	±6·7	±1·5	±0·5	±0·3	±0·2

The liquid layer, situated beneath the superficial layer of lipids, was used for the electrophoresis itself.

For the agar electrophoresis we used Ilkov and Nikolov's version (personal communication) of Grabar's technique, slightly modified. Instead of Grabar's original cuvettes, we used our ordinary containers for paper electrophoresis[3] with platinum electrodes.

The dimensions of the glass plate were 23·5 cm. × 11·5 cm. The agar is poured on a plate, which was held horizontally in 'Plexiglass' frames pressed against the plate itself. Double strips of filter paper were previously placed along the two shorter sides of the plate. The agar layer was 3 mm. thick (45 cm.^{3} for each plate). Three grooves (2 cm. × 1 mm.) were cut from each plate and their bottoms carefully covered with diluted agar (0·30–0·50 per cent). Dittmer's[4] veronal–sodium acetate buffer (*p*H 8·6, $\mu = 0{\cdot}06$) was used. The ionic strength of the buffer in the agar gel was half that in the chamber. A sheet of filter paper was placed in contact with the underside of the plate, the ends of the sheet being dipped in water in order to cool the plate. During electrophoresis the 'Plexiglass' frame is covered with a glass plate which is turned every 20–30 min. A spread of 10–12 cm. was recorded after a 5-hr. migration at 180–200 V. by staining with amido-black 10*B*. The electropherograms were scanned with the Zeiss extinction registrator II.

Livers of 21 experimental animals were investigated. Except in a few cases, two parallel electropherograms were run in each case.

Thirteen well-defined fractions were established. These were designated with the letters *a* to *m*, beginning with the globulin fractions and ending with the albumin fraction (Figs. 1 and 2, Table 1).

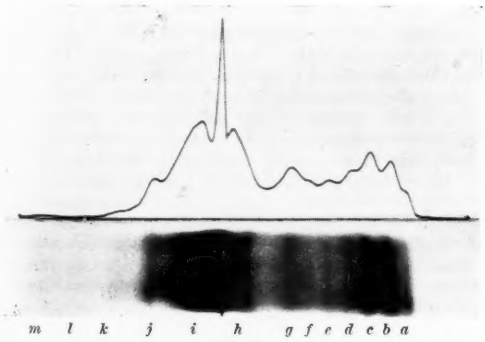

Fig. 1

Fig. 2

We preferred to label these fractions in the direction opposite to that which is customary because the initial globulin fractions were the best defined. Fraction *a* is situated a little behind the γ-globulin, whereas fractions *l* and *m* are in front of the albumins of the blood serum.

The interrelations between the remainder of the hepatic fractions observed and the protein fractions of the blood serum can be seen in Fig. 2. Fractions *k*, *l* and *m* occur in negligible quantities and are often scarcely established. Fraction *i* in Fig. 1 is not sharply delimited from fraction *h*. In other cases it was clearly delimited, so that its existence is out of doubt. A separate fraction migrating beyond fraction *a* (fraction *a'*) was established in certain cases. In one instance, we found a fraction migrating faster than fraction *m* (fraction *n*). With these, the total number of fractions observed by us was 15. In view of the fact that fraction *i* is not clearly delimited, however, it is probably composed of a few subfractions. It is possible that this may be the case with fraction *h* also. Thus the actual number of soluble hepatic protein fractions may be still greater.

The average percentage values for the different fractions and the average standard deviations of their respective variation lines are given in Table 1.

A few of the electropherograms were tested for lipoproteins by staining with 'Fettrot'–7–*B* Ciba[3]. A small amount of lipoprotein could be detected in fraction *i* only.

Thus our results show that, in the separation of soluble hepatic proteins, agar electrophoresis has certain advantages as compared to free electrophoresis and to electrophoresis on paper.

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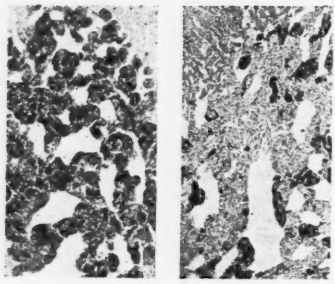
Abolition by Chlorpromazine of the Inhibiting Effect of Iproniazid on the Depletion of Adrenal Catechol Amines induced by Reserpine

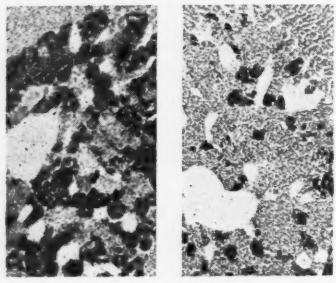
It is well known that reserpine induces a decrease of catechol amines in the adrenal medulla[1–5]. In the rat pretreatment with iproniazid, a monoamine oxidase inhibitor, completely overcomes this catechol amine depletion[6–8].

In the present study the modifications of the catechol amine content of the adrenal gland have



(a) (b)

Fig. 1. Adrenal medulla of rat. Chromaffin reaction. (*a*) A normal degree of chromaffinity is detected in all cells after administration of iproniazid and reserpine. (*b*) After administration of chloropromazine in association with iproniazid and reserpine numerous islets of cells completely devoid of chromaffin material are observed. (× 44)



(a) (b)

Fig. 2. Adrenal medulla of rat. Chromaffin reaction. After association of chlorpromazine to the reserpine (*b*), a higher number of chromaffin-negative cells is observed compared to that detected after administration of reserpine alone (*a*). (× 44)

been investigated when chlorpromazine is added together with reserpine and iproniazid.

40 male albino rats, Wistar stock, weighing approximately 250 gm. were divided into five groups. Animals of the first three groups were treated respectively with: (1) iproniazid (100 mgm./kgm.); (2) chlorpromazine (20 mgm./kgm.); (3) chlorpromazine (20 mgm./kgm.) and iproniazid (100 mgm./kgm.). After 5 hr. all the animals were given reserpine in a dose of 1 mgm./kgm. The animals of the remaining two groups were treated with chlorpromazine only (20 mgm./kgm.) or with reserpine only (1 mgm./kgm.). The drugs were injected intraperitoneally. Animals were killed by decapitation 24 hr. after the last injection. The adrenal glands were removed immediately after death and then treated with a potassium dichromate–chromate solution.

In the adrenals of rats treated with reserpine the chromaffin reaction shows many groups of cells completely devoid of positive granules irregularly distributed through the normally stained parenchyma (Fig. 2*a*). On the other hand, in the rats treated with iproniazid and reserpine, all the cells of the adrenal medulla show a positive chromaffin reaction similar to that observed in the normal gland (Fig. 1*a*).

The administration of chlorpromazine and iproniazid before reserpine causes consistent changes as compared with the findings observed after the administration of iproniazid and reserpine alone. In these circumstances several groups of cells completely devoid of chromaffin material can be detected (Fig. 1*b*); moreover, the number of the non-chromaffin cells is considerably larger than in glands of animals treated with reserpine alone. Similar results were obtained for the adrenals of rats treated with reserpine and chlorpromazine (Fig. 2*b*). Chlorpromazine alone does not cause any significant changes in the chromaffinity of the medullar cells.

These results demonstrate that the inhibiting effect of iproniazid on the adrenaline and noradrenaline depletion induced by reserpine can be abolished by chlorpromazine; moreover, this substance alone does not deplete the catechol amines of the adrenal medulla. Since chlorpromazine also increases the depletion of catechol amines following reserpine administration, one could assume that this drug can not only protect the monoamine oxidase from the inhibitory effect of iproniazid but also increases the enzyme activity.

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Destruction of Carotenoids in Isolated Chloroplasts

Booth[1] has recently directed attention to the various mechanisms which are responsible for carotenoid destruction in green tissues, two of which, a photochemical reaction and an enzymic reaction, have been examined in alfalfa leaf macerates[2]. Enzymic destruction of β-carotene is reported to be greatest in plant tissues containing chlorophyll[1], and we have therefore made a preliminary examination of the destruction of endogenous carotenoids in isolated chloroplast suspensions prepared from leaves of spinach beet.

Leaves were ground at −1° C. in a medium consisting of 0·5 *M* sucrose, 0·067 *M* phosphate buffer (*p*H 7·3), and 0·01 *M* potassium chloride. Whole cells and debris were removed by centrifugation at 200*g* for 1 min.; chloroplasts were sedimented by centrifugation at 1,000*g* for 10 min., washed once, and re-sedimented before final resuspension in the medium. Carotenoids were extracted from the chloroplasts with acetone, separated chromatographically and estimated spectrophotometrically[3]. The destruction of carotenoids in the chloroplasts was measured by comparing the amounts present before and after reaction.

In order to separate the effect of light from that of heat on the destruction of carotenoids, the experi-

ments on illuminated preparations were carried out at 16° C. with illumination from a 100-watt incandescent lamp with a water-cooled condenser. For the dark controls, tubes were covered with aluminium foil.

When non-aerated chloroplast suspensions were illuminated, 6 per cent of the β-carotene disappeared in 30 min., compared with 4 per cent in the dark. Since none disappeared in boiled suspension the reaction was probably enzymic. Bubbling air through the chloroplast suspensions increased the light-catalysed destruction of β-carotene to 27 per cent, while in the dark 14 per cent disappeared. The relative rates of disappearance of the individual carotenoids were β-carotene > violaxanthin ⩾ lutein; the last only started disappearing after 1 hr. The order of disappearance of these carotenoids is the same as that of the disappearance of carotenoids in autumn leaves[4].

The addition of Hill reaction oxidants to spinach beet chloroplast suspensions gave varying results. 2,6-Dichlorophenol indophenol[5] reduced the destruction of β-carotene in non-aerated chloroplast suspensions to 2 per cent (controls 6 per cent), whereas ferric oxalate–potassium ferricyanide solution[6] increased the destruction to 19 per cent. The ferric oxalate–potassium ferricyanide solution had no effect on the destruction of β-carotene in the presence of light and air, but when coupled with the addition of phenazine methosulphate[7] there was measurable inhibition of carotene destruction. β-Carotene destruction was stimulated by the addition of *ortho*-phenanthroline[8] to the ferric oxalate–potassium ferricyanide solution in the presence of light and air. When zinc acetate[8] was also added, there was a further increase of β-carotene destruction. This result was contrary to expectations since zinc acetate reverses the inhibitory effect of *o*-phenanthroline on the Hill reaction[8].

Further experiments on non-illuminated preparations were carried out in which leaf preparations were shaken in a water-bath at 30° C. in the dark. The activity of chloroplasts from different batches of leaves varied considerably; in some chloroplast preparations 20 per cent of the β-carotene disappeared, whereas in others 50 per cent disappeared, after 1 hr.

The enzymic destruction of carotene in chloroplasts in the dark at 30° C. was inhibited by phenazine methosulphate. *o*-Phenanthroline had no effect, but, in the presence of zinc acetate, *o*-phenanthroline greatly stimulated carotene destruction. These effects are somewhat comparable to those found in the light-catalysed destruction and suggest some similarity between the two processes.

In an attempt to locate the enzymic system responsible for destruction of β-carotene, a comparison was made of the disappearance of β-carotene in leaf homogenates, chloroplasts prepared from them, and the supernatant fraction which still contained broken chloroplasts. In spinach beet leaves there was an almost equal destruction in all three fractions, suggesting that the enzyme system responsible for the destruction was closely linked to the pigment–protein complexes. In sugar beet leaves, however, there was more destruction of β-carotene in both the homogenate and the supernatant than in the chloroplast fraction. This could be due to the fact that in sugar beet leaves there are at least two differently located enzyme systems responsible for carotene destruction, which would be in accord with more recent findings (Faiend, J., and Mayer, A. M., unpublished work).

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Use of Porter–Silber and Schiff Reagents as Spot Tests for Steroids applied on Paper and their Application to the Study of Rat Adrenal Lipids

The formation of phenylhydrazones with an absorption maximum at 410 mμ by the method of Porter and Silber characterizes steroids with a dihydroxyacetone side-chain. These authors recently reported that the reaction also occurred with the aldehydes of corticosterone and of 11-dehydrocorticosterone and that with the latter compounds the phenylhydrazone developed at a more rapid rate[1]. The specificity and difference in speed of the reaction are also evident when it is carried out on paper. A bright yellow colour develops when a region containing a minimum of 2 μgm./cm.² of the chromogen is passed through the Porter–Silber reagent (25 ml. water, 41 ml. conc. sulphuric acid, 34 ml. ethyl alcohol and 43 mgm. phenylhydrazine hydrochloride). The colour appears instantly with C-21 aldehydes and their acetates, and in 1–2 hr. with steroids containing the dihydroxyacetone side-chain and their acetates. It is stable for days provided the paper is not rinsed or warmed, and under these conditions the paper does not char. Corticosterone, 17-hydroxyprogesterone and other steroids tested gave no colour at a concentration of 25 μgm./cm.².

C-21 aldehydes, freshly prepared by oxidation with cupric acetate after the method of Beyler and Hoffman[2], may be detected with a Schiff reagent (1 per cent pararosaniline hydrochloride in sulphurous acid), if 10 μgm. have been applied over an area of 1 cm.². A purple colour appears as the rest of the paper turns pink. The development of the same purple colour in the rest of the paper may be delayed for a few days by encasing the paper in 'Scotch' tape. Steroids with an α-ketol- and a dihydroxy-acetone side-chain gave no reaction in amounts of 50 μgm./cm.², neither did a sample of aldosterone kindly supplied by Merck and Co. It is to be noted that freshly prepared aldehydes react at a lower concentration than material which has been stored in the refrigerator or chromatographed in the toluene–propylene glycol system.

Both tests have proved helpful in the synthesis and purification by paper chromatography of steroid C-21 aldehydes. When a region on paper gave a positive reaction to the two tests and failed to reduce a tetrazolium derivative, the presence of an aldehyde was assumed.

The sensitivity and simplicity of the Porter–Silber spot-test should make it a useful tool for the detection of Porter–Silber chromogens in lipid extracts of biological fluids. The test has helped in establishing the facts that the incubated rat adrenal secretes little, if any, cortisol or cortisone[3], that the non-reducing, lipid-soluble Porter–Silber chromogen produced by this tissue has the same mobility in the toluene–propylene glycol system as the aldehyde of 11-deoxy-17-hydroxycorticosterone, and that acetylation of the adrenal lipid yields two ultra-violet-absorbing, non-reducing Porter–Silber chromogens; a component with the same mobility in the benzene-formamide system as a product obtained by acetylation of 11-deoxy-17-hydroxycorticosterone aldehyde, and a more polar material[4].

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Some Observations on Certain Mucoproteins containing Neuraminic Acid

It is now well established[1–4] that mucoproteins, particularly those containing neuraminic acids, play a major part in the natural defences of the human body. With the object of determining what part is played by such mucoproteins in human cancer we have assessed the amount and distribution of mucoproteins containing neuraminic acid by determination of the neuraminic acid content of tissues obtained in surgical operations for cancer of the stomach, colon and breast, and compared these with those of tissues obtained during removal of ulcers of the stomach and duodenum.

Each portion of tissue was extracted exhaustively at room temperature with acetone and later with methanol–chloroform (3 : 1 v/v) in order to remove any neuraminic acid-containing gangliosides. Part (50 mgm.) of the fat-extracted residue was suspended in water and dialysed against 0·01 *N* sulphuric acid at 0° for 2 days. The neuraminic acid(s) in the non-dialysable residue was then liberated by heating at 80° for 1 hr. with 0·04 *N* sulphuric acid and recovered from the neutralized solution by dialysis. The neuraminic acid determination[5] was carried out on this dialysate to avoid interference due to chromogens from other sugars.

When the whole of the surgical tissue from each operation was examined in this way the neuraminic acid contents of two carcinomas (0·33 and 0·43 cent) from the pylorus end and one (0·64 per cent) from the cardia end of the stomach were appreciably higher than those (0·11, 0·13 and 0·14 per cent) of three stomach ulcers or those (0·12, 0·16 and 0·18 per cent) of three duodenal ulcers. In a more meaningful comparison the tissues obtained from later cancer operations were arbitrarily divided into three portions: (*A*) the cancerous or centre of the malignant growth; (*B*) the invasive area in which there is an interlocking growth of the normal and cancer cells; (*C*) the apparently 'normal' area outside. The results are given in Table 1.

Table 1. Neuraminic Acid Content in Various Areas of a Malignant Growth

Type of carcinoma	Percentage neuraminic acid content in area: *A*	*B*	*C*
Adenocarcinoma of the colon	0·24	0·26	0·17
Carcinoma of the pylorus and duodenum	0·18	0·18	0·11
Scirrhous carcinoma of the breast	0·29	0·11	0·13
Duct carcinoma of the breast	0·16	0·15	0·08

Bearing in mind the difficulty of deciding on the so-called invasive area and the obvious variation in such an arbitrary division, it is nevertheless evident that the amount of mucoprotein containing neuraminic acid is almost doubled in the area of malignancy.

Several types of neuraminic acids (N-acetyl-, N,O-diacetyl-, N-glycolyl-, etc.) have now been recognized. Paper chromatographic and ionophoretic analysis revealed that the neuraminic acid liberated by hydrolysis of the tissue from two stomach ulcers, a duodenal ulcer, a carcinoma of the pylorus, and from all three areas (*A*, *B*, and *C*) of the colon adenocarcinoma and the scirrhous breast carcinoma was N-acetyl neuraminic acid. Both N-acetyl and N,O-diacetyl neuraminic acid were liberated from a malignant tumour situated at the cardia end of the stomach and involving 1 in. of the œsophagus.

In another aspect of this assessment of the distribution of carbohydrate-containing substances in human tumours we have determined[6] the hexosamine contents of some of the tissues studied above. Mucoproteins almost always contain hexosamines, but the hexosamine content of the tissue should not necessarily follow the neuraminic acid values since hexosamines are also components of blood group polysaccharides and many tissue polysaccharides. The carcinoma obtained from the cardia end of the stomach which had the highest neuraminic acid content (0·64 per cent) also had the highest hexosamine content (3·3 per cent) of those studied. The distribution of hexosamine (1·8 per cent in *A*, 1·6 per cent in *B* and 1·2 per cent in *C*) in the colon adenocarcinoma also followed that of the neuraminic acid content. However, the hexosamine content (2·1 and 2·0 per cent) of the whole of the surgical tissue from two stomach ulcers and that (2·3 per cent) of a duodenal ulcer differed little from that (2·2 per cent) of the carcinoma of the pylorus. Analysis[7] revealed that glucosamine and galactosamine were the only amino-sugars present in the duodenal ulcer (glucosamine : galactosamine, 1·9 : 1) and in the carcinomas from the pylorus end (glucosamine : galactosamine, 2·1 : 1) and from the cardia end (glucosamine : galactosamine, 2·3 : 1) of the stomach. Trypsin digestion[8] of the fat-extracted tissues from the same duodenal ulcer and the two stomach carcinomas, removal of protein with trichloracetic acid and addition of alcohol gave crude polysaccharide mixtures in yields of 2·2, 2·1, and 2·3 per cent

respectively. Acid hydrolysis of these mixtures liberated hexosamines, fucose, and galactose together with small amounts of glucose and mannose. This suggests that most of the polysaccharide in these tissues was of the blood-group substance type. The glucose probably originated from the glycogen[9] which constituted 0·35 per cent of the duodenal ulcer tissue and 0·30 and 0·29 per cent respectively of the stomach carcinomas (all yields calculated on the dried fat-extracted tissue). Ionophoretic analysis of the crude polysaccharide mixtures revealed the presence of small amounts of acidic polysaccharides staining with toluidine blue[10] accompanied by much larger amounts of neutral polysaccharides.

We are indebted to the staff of the West Bromwich and District General Hospital, West Bromwich, Staffs, for the provision of tissues. We have also had valuable discussion with Prof. J. W. Orr and Dr. D. L. Woodhouse of the Cancer Research Laboratories. One of us (D. J. T.) thanks the University of Birmingham for the award of a scholarship. The research was supported by a grant from the British Empire Cancer Campaign.

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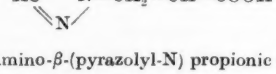
α-Amino-β-(pyrazolyl-N) Propionic Acid : a New Amino-Acid from *Citrullus vulgaris* (Water Melon)

During recent years, several new amino- and imino-acids have been characterized as components of the non-protein nitrogen fraction of plant materials. Another example has now been found in seeds of *Citrullus vulgaris* (water melon, var. Tom Watson). The structure of this new amino-acid (hereafter termed βPA) is as follows :



α-Amino-β-(pyrazolyl-N) propionic acid
or β-(pyrazolyl-N) alanine

This amino-acid is unique in that it is the first example of a natural product which contains a pyrazole ring. Furthermore, in contrast to the other heterocyclic ring-containing amino-acids, histidine and tryptophan, the side-chain of βPA is attached to the pyrazole ring through a carbon to nitrogen bond.

The presence of the amino-acid was detected by two-dimensional paper chromatography (water-saturated phenol : butanol/acetic acid/water) in a 70 per cent (v/v) ethanol extract of ground seeds. It occupied a position very similar to that of proline on two-dimensional chromatograms. The compound reacted with ninhydrin to give a normal bluish-purple spot. With Ehrlich's reagent (*p*-dimethylaminobenzaldehyde) it gave a yellow-coloured spot, and it formed a copper complex with copper acetylacetonate, so indicating the presence of an α-amino group.

By ion exchange chromatography ('Zeokarb 215' and 'Dowex 50'–0·25 *N* ammonia displacement), 3 gm. of βPA was isolated from 10 lb. of water melon seeds. The amino-acid was crystallized twice from distilled water (solubility approximately 4 gm./100 ml.), and yielded a white solid with an elemental analysis of C, 46·7 ; H, 5·7 ; N, 27·1 ; O (by difference), 20·4. The calculated values for βPA are C, 46·4 ; H, 5·8 ; N, 27·0 ; O, 20·8.

Therefore, the isolated material had an empirical formula of $C_6H_9N_3O_2$, and was isomeric with histidine. This formula provides too few hydrogen atoms for the more normal saturated open-chain amino-acid structure. The compound was found to be stable to strong mineral acid (6 *N* hydrochloric acid at 100° for 24 hr.) and alkali (5 *N* barium hydroxide at 100° for 24 hr.). Treatment of the isolate with 55 per cent (w/w) hydriodic acid at 120° for 24 hr. degraded it, and alanine was identified as the only ninhydrin-reactive product by comparison with an authentic sample of the amino-acid on paper chromatograms developed in water-saturated phenol, butanol/acetic acid/water mixture, butanol saturated with 2 *N* ammonia, and ethyl acetate/pyridine/water (organic phase of 2 : 1 : 2 parts by volume mixture). The fission of an alanine moiety in this way not only indicated its presence in the structure of the isolate but also suggested that the alanine residue was attached to the remainder of the molecule through a C—N linkage (the corresponding C—C linkage found in histidine is stable to hydrogen iodide reduction).

The remaining atoms of the formula are most simply accommodated by assuming the presence of an imidazole or pyrazole ring system. It would appear that Shinano and Kaya[1] have isolated a smaller quantity of the same substance from the press-juice of water melon ; both isolates had the same elemental analysis and m.p. (decomp.) in the range 236–238° C. The Japanese workers suggested that their isolate was α-amino-β-(imidazolyl-N) propionic acid, although no definite proof for the presence of the imidazole residue was given. Our evidence provides no support for the idea of an imidazole ring. The isolate failed to give the Pauli test, and did not possess a *pK* in the *p*H range 6–7, normally a feature of imidazole derivatives. Pyrazole derivatives have an analogous *pK* in the *p*H range 2–3 ; the titration curve of the isolate showed a weak point of inflexion in this range. Nuclear magnetic resonance spectra[2] performed on the isolate and various N-substituted imidazole and pyrazole derivatives proved almost certainly that the isolate contained the pyrazole ring system. The fine structure of the spectrum of the isolate also indicated an unsubstituted α-amino group in the alanine residue and the presence of a $—CH_2—$ group and an N—C linkage. These requirements are all met by the above structure for βPA.

Crude, small-scale preparations of β*PA* and β-(imidazolyl-*N*) alanine (β*IA*) have been made. The silver salts of pyrazole and imidazole respectively were refluxed in methanol with the methyl ester of β-chloroalanine hydrochloride (prepared by the method of Fischer and Raske[3]). After removal of the methanol and hydrolysis with 6 *N* hydrochloric acid, the reaction mixtures contained three amino-acids. Serine and a trace of a compound, probably alanine, accompanied either β*PA* or β*IA*. The synthetic β*PA* was inseparable from the isolated material on paper chromatograms, whereas β*IA* was easily resolved from the isolate. β*IA* had an R_F very similar to that of histidine in water-saturated phenol; in butanol/acetic acid/water mixture it moved slightly more slowly than histidine. The yields obtained in these preparations were low, but it is hoped that a future large-scale preparation of β*PA* may provide sufficient crystalline material for comparisons to be made with the natural substance using other accepted physico-chemical techniques.

We wish to thank the Ferry-Morse Seed Co. (California) for supplying the seed, Dr. I. L. Finar for advice on the syntheses, and Drs. J. H. Ridd and R. F. M. White for their help with the nuclear magnetic resonance spectra.

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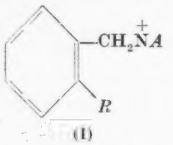
ANIMAL PHYSIOLOGY

New Antiadrenergic Compounds

We have found that the benzyl quaternary ammonium compounds (I, patents pending) have a novel and highly specific blocking action on the peripheral sympathetic nervous system, which resembles that following section of adrenergic nerves and differs from that produced by adrenolytics, ganglion-blocking agents and reserpine.



(I)

Compounds of the above type were screened by examining their efficacy in relaxing the nictitating membrane when injected subcutaneously in the cat. Activity was highest in the quaternary compounds (I; R = H) and the *ortho*-substituted analogues (I; R = *Me*, F, Cl, Br, I, and NO_2). Activity was also very sharply influenced by the cationic head, high activity being encountered in the compounds I with $NA = NMe_2Et$, $NMe_3(CH_2)_2OH$, $EtN(CH_2)_4$, $HO(CH_2)_2N(CH_2)_4$. Lower homologues such as I with $NA = NMe_3$, R = Br were inactive and higher homologues showed much reduced activities. There was no mydriasis or other overt effect in cats injected with any of these compounds, except one (I; $NA = NMe_2Et$, R = H) which caused marked parasympathomimetic effects.

One of the most active compounds, 373*C*57 (I; $NA = NMe_2Et$, R = Br), was examined in detail, as its bromide, and the findings indicating its mode of action are summarized as follows.

After subcutaneous injection of 5–10 mgm./kgm. of 373*C*57 in the unanæsthetized cat, the nictitating membrane gradually relaxed, becoming fully exposed in 4–6 hr., and retracted only after approximately 24 hr. Similarly, in cats under chloralose anæsthesia, 373*C*57 gradually inhibited the effect of indirect stimulation of the nictitating membrane irrespective of whether the stimuli were applied to the pre- or post-ganglionic nerve; the block was most marked when the stimulation was continuous. This inhibitory effect was accompanied by a gradual and prolonged fall in blood pressure often preceded, when the drug was given intravenously, by a small temporary rise. The response of the heart to stimulation of the cardio-accelerans nerve was blocked, and the pressor effects of intravenous injections of adrenaline and noradrenaline were increased.

373*C*57 blocked the response to stimulation of the adrenergic nerve in various isolated preparations. Thus it prevented the vasoconstriction caused by stimulating the greater auricular nerve in the perfused rabbit ear, the relaxation of the rabbit ileum during stimulation of the visceral efferents, and the contraction of the rabbit uterus elicited through the hypogastric nerve. The effects of adrenaline and noradrenaline on these preparations were enhanced after giving 373*C*57.

In the cat, the pressor effects of intravenous dimethylphenylpiperazinium iodide and splanchnic nerve stimulation which are mediated by the adrenal medulla were greater after giving 373*C*57, whereas the hypertension caused by the ganglion-stimulating action of dimethylphenylpiperazinium iodide in the adrenalectomized animal was blocked. This shows that the antiadrenergic action of 373*C*57 is not accompanied by an interference with the adrenal mechanism, such as occurs with the ganglion-blocking drugs or reserpine.

Some of the properties of 373*C*57 resemble those of the 2 : 6-xylylether of choline bromide, *TM*10[1,2], but unlike this compound, 373*C*57 does not cause parasympathomimetic effects or deplete the pressor amine content of the rat adrenal. The latter finding, if it applied also to the adrenergic nerve, would indicate that it is unlikely that 373*C*57 acts either by depleting the local stores of catechol amines or by inhibiting the biogenesis of noradrenaline in adrenergic nerves, as was postulated[3] might be the mode of action of *TM*10. 373*C*57 caused no overt behavioural changes in animals, and this together with the absence of depletion of the catechol amine content of the adrenal medulla of rats is in contrast with the actions of reserpine.

Together with our colleagues, Drs. A. McCoubrey and W. G. Duncombe, we have studied the distribution in tissues of 373*C*57 labelled with carbon-14 in one of its methyl groups. Following subcutaneous injection in cats, much higher concentrations of radioactivity were found in adrenergic nerves, sympathetic ganglia and tissues with a rich adrenergic innervation, than in other tissues. The concentration of 373*C*57 indicated to be present in adrenergic nerves, when applied topically, blocked the physiological responses to stimulation of the pre- and post-ganglionic cervical

sympathetic nerves in the cat, the visceral adrenergic nerves of rabbit intestine, and the greater auricular nerve in the rabbit ear.

We conclude that the blocking effect of 373*C*57 on the peripheral sympathetic nervous system is due to an action on adrenergic nerves and that its specificity is related to the selective accumulation of the compound in adrenergic nerves following systemic administration.

The properties of 373*C*57 and related antiadrenergic compounds may render them useful for the reduction of sympathetic tone, for example, in the treatment of hypertension; they do not impair parasympathetic functions as do ganglion-blocking agents, nor depress the central nervous system as does reserpine.

Note added in proof. We have just learned that the open name, approved by the British Pharmacopœa Commission, for 373*C*57 *p*-toluene sulphonate is 'bretylium tosylate'.

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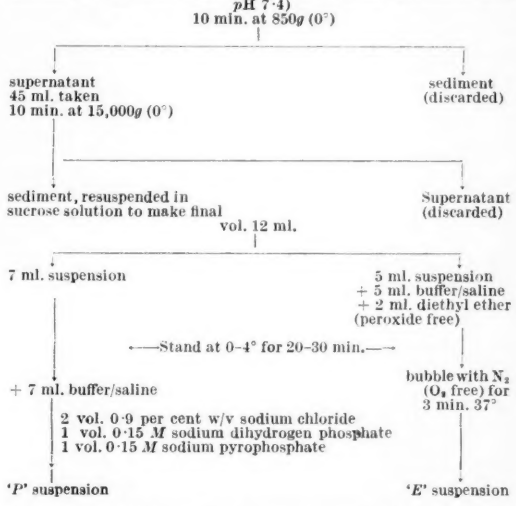
Action of Ganglion Blocking Drugs on Choline Acetylase

The first practical hypotensive drugs which acted by causing autonomic ganglionic block were *bis*-quaternary ammonium salts; recently, substances containing only a single secondary or tertiary amine group have been introduced as hypotensive agents of a similar type. There are, however, differences in the details of the pharmacological actions of the two types of drugs; for example, the mono-amine compounds, mecamylamine and pempidine, are slower in onset of action but more prolonged when compared with the older group (for example, hexamethonium or pentolinium). The *bis*-quaternary ammonium drugs paralyse ganglia by extracellular competition with acetylcholine for synaptic receptor sites; the differences in action might be explicable if the newer compounds acted in some other way, for example, by inhibition of acetylcholine formation. Their ability to penetrate cell lipid membranes or barriers makes such an intracellular action plausible.

Choline acetylase preparations from guinea pig brain have therefore been used to compare the effects of three of these mono-amine compounds with those of a 'hemicholinium' (*HC*-3), a compound which is known to owe its high toxicity to interference with acetylcholine synthesis[1-2]. The enzyme preparations used were modifications of those previously employed and were more dependent on the addition of choline for their activity. *HC*-3 inhibits only the weaker '*P*' preparation; this action results from its competition with choline for some limited path of entry into the less damaged particles of that preparation[2].

The three mono-amine compounds tested (mecamylamine, pempidine, and its ethyl analogue, Imperial Chemical Industries Cpd. 26539), showed no significant inhibition of either enzyme preparation when tested in the concentration (10^{-4} *M*) at which *HC*-3 reduces the activity of the '*P*' preparation by one

Particulate Choline Acetylase Preparations from Guinea Pig Brain


Chilled fresh brains homogenized (0–4°) in 9 vol. 9 per cent w/v sucrose (10^{-3} *M* with respect to ethylenediamine tetraacetic acid, *p*H 7·4)
10 min. at 850*g* (0°)
supernatant
45 ml. taken
10 min. at 15,000*g* (0°)
sediment
(discarded)
sediment, resuspended in sucrose solution to make final vol. 12 ml.
Supernatant
(discarded)
7 ml. suspension
5 ml. suspension
+ 5 ml. buffer/saline
+ 2 ml. diethyl ether (peroxide free)
Stand at 0–4° for 20–30 min.
+ 7 ml. buffer/saline
bubble with N_2 (O_2 free) for 3 min. 37°
2 vol. 0·9 per cent w/v sodium chloride
1 vol. 0·15 *M* sodium dihydrogen phosphate
1 vol. 0·15 *M* sodium pyrophosphate
'*P*' suspension
'*E*' suspension

half. Pempidine was also ineffective at 10^{-3} *M*, a concentration which would be expected to reveal any ability to interfere specifically with the enzyme system.

The response of the frog rectus abdominis muscle used to assay acetylcholine was affected by the presence of the drugs, especially by mecamylamine; and it was necessary, to prevent a progressive reduction in sensitivity, to adopt a routine of regular repeated washing and resting of the tissue after each estimation.

Contrary to the results reported here, a brief note[3] appeared earlier indicating that mecamylamine can inhibit acetylcholine formation; but recent discussion with the authors has clarified the position. The suggestion arose from preliminary experiments in which a soluble choline acetylase was used, prepared from an acetone powder of rabbit brain, the acetylcholine formed being estimated colorimetrically. Mecamylamine was used in amounts equimolar with choline, and since the assay method adopted necessitates a high choline concentration (10^{-2} *M* or more) there was a serious possibility that the inhibition was non-specific. Subsequent studies with other secondary amines confirmed this and the work was discontinued.

In their investigation of pempidine, Corne and Edge[4] showed that a large dose (10 mgm.) could reduce by 40 per cent the acetylcholine output from the cat's perfused superior cervical ganglion in response to pre-ganglionic stimulation. Their experi-

Table 1

	'*P*' preparation	'*E*' preparation
Average acetylcholine content n.mole/ml. suspension	1·7 (1·3–2·5)	0·16 (0·0–0·5)
Average net synthesis of acetylcholine n.mole/ml. suspension	5·0 (4·0–5·7)	21·4 (19·7–24·7)

Reaction system contained in 2 ml. 0·1 μmole acetyl-coenzyme *A*: 0·05 μmole choline chloride, 2 μmoles tetraethyl pyrophosphate, 0·2 μmole inhibitor (if any), 50 μmoles sodium dihydrogen phosphate, 50 μmoles sodium pyrophosphate, 1 ml. '*P*' or '*E*' enzyme suspension. Incubation for 1½ hr. at 37° with gentle shaking. After incubation reaction stopped by acidification and heating, alkali-treated controls prepared and the acetylcholine content assayed on frog rectus abdominis muscle preparation sensitized with tetraethyl pyrophosphate.

Table 2

Compound	Concentration (*M*)	Activity of control (per cent)	
		'*P*' preparation	'*E*' preparation
Mecamylamine*	10^{-4}	106, 107, 98	104, 100, 98
Pempidine†	10^{-4}	89, 105, 86	105, 103, 125
Pempidine†	10^{-3}	102	107
26539†	10^{-4}	100, 100	95, 95
HC-3	10^{-4}	47, 80, 40, 57, 50	83, 105, 101, 100, 117

* Used as hydrochloride.
† Used as tartrate.

ments were of short duration when compared with the time required to show the reduction produced by *HC*-3 on the same preparation[1]. The effect seen by Corne and Edge could well be due to a slight local anæsthetic action[5], common among amines.

Thus the experiments described here give no support to the hypothesis that the ganglion-blocking agents mecamylamine, pempidine or 26539 act, even in part, by inhibition of acetylcholine formation. They affect neither the simple choline acetylase activity of preparation '*E*' nor, in preparation '*P*', the additional limiting step of choline entering the particles.

I am grateful to Dr. A. Spinks, Imperial Chemical Industries, Pharmaceuticals Division, for the pempidine and compound 26539 used in this work.

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April 9.

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PLANT PHYSIOLOGY

Effect of Gibberellic Acid on the Initiation of Flowers and Runners in the Strawberry

A number of long-day responses are induced by the application of gibberellic acid to plants growing in short days. These include the promotion of stem elongation and flower induction in long-day plants[1]; inhibition of flower initiation in some short-day plants[2]; and delay in the onset of autumn colouring and leaf-fall, and renewal of shoot-growth in woody plants[3]. In the strawberry, flowers are initiated under short-day conditions and branch crowns are formed in the axils of the leaf petioles, which are short and prostrate. During long days, flowers are seldom initiated, runners are formed in the leaf axils and the petioles are long and upright. It has been suggested by one of us[4] that this greater vegetative vigour is the result of the production during long days of a growth-promoting hormone. The present experiment demonstrates that gibberellic acid can act as a substitute for this natural product.

Gibberellic acid was applied at 100, 50, 25, 12·5 and 0 p.p.m. to plants of Talisman growing in pots in a glasshouse under natural short days from September 4 until November 19. Temperature was not accurately controlled, but the minimum night temperature fell from the range 55–60° F. in the earlier part of the experiment to 50–55° F. during November. Ten plants were used for each treatment and the gibberellic acid solution, with 'Agral' added as a wetter, sprayed on until run off. For the first three weeks application was weekly, and afterwards at fortnightly intervals.

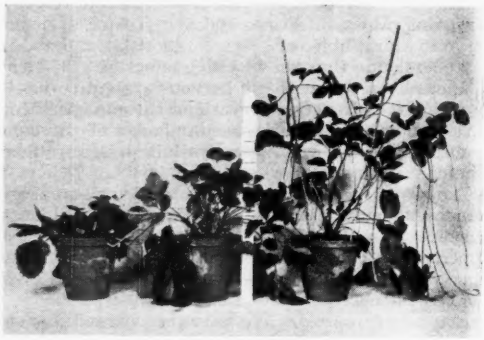

Fig. 1. Effect of fortnightly applications of gibberellic acid to strawberries under short days at 25 p.p.m. and 100 p.p.m. Untreated control on the left

The first effects of treatment appeared after about twelve days as a slight paling of the youngest leaves and a very upright growth of the petioles. Increase in length of the internodes of the main stems occurred a little later. Table 1 shows that the length of the main stem measured over nine internodes from the leaf emerging at the start of treatment was directly proportional to the concentration of gibberellic acid applied. In the controls, the increase in length of the main stem over this period was so small that no satisfactory measurement could be made; it was, however, considerably less than that found at the 12·5-p.p.m. level. Under the conditions of this experiment, length of petiole did not increase with concentration of gibberellic acid to the same degree. In all treated plants the petioles were considerably longer than in the controls, but the response at 12·5 p.p.m. was only a little less than that at 100 p.p.m. The difference in response between petioles and stems is illustrated in Fig. 1.

During November, runners which had failed to emerge were found in the axils of the leaves of some of the treated plants. After the removal of two plants from each treatment for dissection, the remainder were reduced to four main stems each and transferred to a lighter and warmer glasshouse, in which the minimum night temperature was in the range 60–65° F., to encourage the emergence of the runners. As a further aid, the tips were removed from two stems on each plant. To determine whether the emergence of runners was controlled by length of day in spite of the application of gibberellic acid, half the plants were given a light break from 10 p.m. until 2 a.m. using 60-W. incandescent lamps suspended 2 ft. above the bench, and the other half were given short days with similar illumination during the afternoon from 2 p.m. until 6 p.m.

Runners started to emerge immediately under the new conditions, and after twelve days runner emergence was recorded. All the runners counted had been initiated in the natural short-day conditions of the first glasshouse. The number of runners emerging was not affected either by photoperiod or by tipping,

and their failure to emerge earlier must have been the result of poor growing conditions. In Table 1 these secondary treatments have been combined and production of runners is shown as the mean number of runners produced per crown at each level of application. The appearance of the plants three weeks after transfer to the warmer glasshouse is shown in Fig. 1.

Table 1

Gibberellic acid (p.p.m.)	Inflorescences per crown	Runners per crown	Mean length of main stems (mm.)
None	1·00	0·00	—
12·5	0·58	0·25	14
25	0·25	1·16	41
50	0·00	1·22	115
100	0·00	1·59	289

Records for flower initiation were obtained, first from the plants dissected at the time of transfer to the second glasshouse, and second by counting inflorescences emerging after transfer to this house. All the inflorescences counted had been initiated during the course of the natural short-day treatment; these are shown in Table 1 as the mean number of inflorescences per crown at each treatment-level.

All these results, namely, increase in length and upright growth of the petioles, initiation of runners instead of branch crowns, and suppression of flower initiation, are typical of the response of this plant to long-day conditions. It would seem that gibberellic acid can serve as a substitute for a growth-promoting hormone produced naturally under long-day conditions. On the other hand, the fact that complete suppression of flower initiation and the highest level of runner production was not reached until the concentration of gibberellic acid was such that it caused abnormal elongation of the main stems would suggest that the long-day growth-promoting hormone and gibberellic acid are not identical, although they may be closely related.

The gibberellic acid solution used in this experiment was kindly supplied by Plant Protection, Ltd.

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Effect of Indole Acetic Acid and α-Naphthalene Acetic Acid on the Growth, Flowering and Fruit Set in Sweet Potato

Sweet potato (*Impomoea batatas* (L.) Lam.) is cultivated for its tuber and its foliage, which is used as cattle food. It is usually propagated either by the tuber slips or stem cuttings; in India the latter method is usually followed. Hernandez *et al.*[1] reported that the tubers when dipped momentarily in 2,4-D at 10 p.p.m. produced a significantly larger number of plants than the control, but they did not study the effect of the chemical on stem cuttings or on tuber yield. Howell and Wittwer[2,3] observed that 2,4-D sprays induced better flowering in sweet potato. Mikell[4] found that 2,3,5-triiodobenzoic acid, 2,4-D and α-naphthalene acetic acid failed to induce any flowering when the plants were treated either by the wick method, foliage spray or soil application.

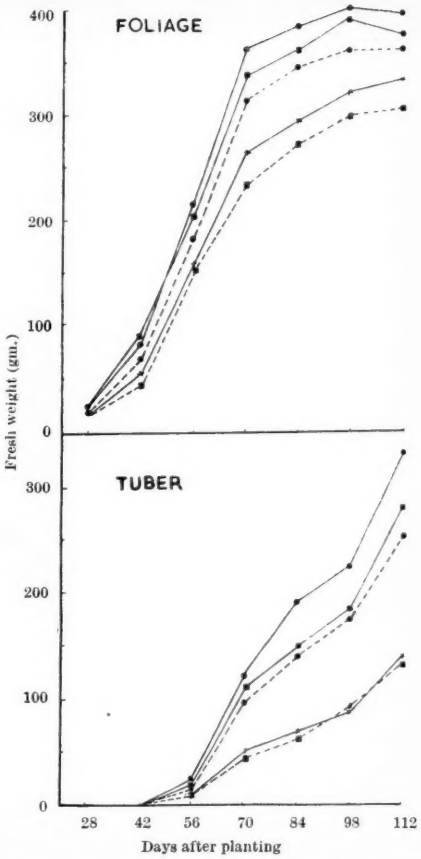

Fig. 1. The influence of indole acetic acid and naphthalene acetic acid on the growth of foliage and development of tubers in sweet potato, as indicated by their fresh weight. Indole acetic acid: ●—●, 25 p.p.m.; ●- - -●, 10 p.p.m. Naphthalene acetic acid: ■—■, 1 p.p.m.; ■- - -■, 25 p.p.m. ×—×, control

Studies were undertaken by us recently to find out the effect of two plant-growth regulators, namely, naphthalene acetic acid and indole acetic acid, on the growth, tuberization, flowering and fruit set in sweet potato. Stem cuttings of uniform thickness and 12 in. in length were selected from a local white variety of sweet potato. The basal ends were immersed up to one inch in various concentrations of the growth regulators in water and in water alone as control. When the cuttings were immersed for 24 hr. in water, root development was inhibited; this did not occur after 12 hr. immersion. Subsequent studies were therefore made by treating the stem cuttings for 12 hr. only. The treated cuttings were washed thoroughly with tap water and planted in a well-prepared field on ridges with a spacing of 24 in. × 12 in.; 60 cuttings were planted from each treatment. The plants were maintained with periodic irrigation and weeding, following the local practice.

Observations on the growth of foliage, tuberization, flowering and fruit set were made at intervals. Three plants were selected at random from each treatment and the growth of shoot and root measured; the amount of tuberization was recorded by carefully digging out the plants, washing the tubers free from soil and taking the fresh weight. Representative samples of the foliage and tubers were collected and the dry weight and moisture percentage estimated. The rates of growth of foliage and roots in terms of their average fresh weights are shown in Fig. 1. All the treatments, except α-naphthalene acetic acid 25 p.p.m., were found to cause better growth of foliage and tuberization, as compared to the controls. Among the treatments, indole acetic acid 25 p.p.m. gave the best results. In general the chemical treatments hastened the growth of foliage, except in the case of 25 p.p.m. naphthalene acetic acid, where there was a definite reduction in the weight (Fig. 1). The treatments produced no significant difference in the moisture content of foliage or tubers. The tubers in plants treated with indole acetic acid were characterized by linear developments, whereas with naphthalene acetic acid no such effect was observed.

All the treated plants flowered earlier and comparatively more than in the controls. There was also more fruit set in all the treated plants, indole acetic acid at 10 p.p.m. giving the best results (Table 1). The seeds on maturity were collected separately and on testing were found to germinate 100 per cent, giving rise to normal plants.

Table 1. The Effect of Indole Acetic Acid (IAA) and Naphthalene Acetic Acid (NAA) Treatments on the Flowering and Fruit Set in Sweet Potato

Treatment (p.p.m.)	First flowering after (days)	Average No. of flowers per plant	Average fruit set per plant	Fruit set (per cent)
Control : 0	79	80	*	—
IAA : 1	55	136	24	17·6
10	50	180	38	21·1
25	57	115	19	16·5
NAA : 1	71	96	16	16·6
10	64	121	14	11·6
25	65	111	10	9·0

* Occasionally one or two fruits were found set in a few plants, which might be due to open pollination.

Seed setting in sweet potato seems to be rare under natural conditions[5,6]. The results obtained in the present work indicate the possibility of increasing the foliage and tuber yields as well as increasing the flowering and fruit set by treating the stem cuttings with plant-growth regulators before planting. Further studies are in progress.

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ANIMAL PATHOLOGY

Effect of Proflavine on the Formation of the Virus of Foot-and-Mouth Disease and its Infective Ribonucleic Acid in Pig Kidney Tissue Culture Monolayers

Proflavine inhibits the growth of bacterial viruses by blocking some process or processes connected with the formation of the infective virus particle from its sub-units. Antigens, specific to the virus, are still synthesized in the presence of proflavine although fully infective virus particles are not produced. These observations have also been made with some animal viruses (vaccinia[1,2], fowl plague[3], poliomyelitis[4]). The action of proflavine is regarded as being due to the inhibition of cytoplasmic protein synthesis, but Dulbecco and Vogt[5] have shown that low concentrations of proflavine induce mutations in the virus of poliomyelitis, so the compound probably has some action on the nucleic acid of this virus.

As it has recently been shown[6] that infective ribonucleic acid can be obtained from pig kidney tissue culture cells infected with the virus of foot-and-mouth disease before fully infective virus is formed, it was considered that it would be of interest to study the effect of proflavine on the synthesis of infective virus and its ribonucleic acid in this cell system. Pig kidney cells grown in monolayers were infected with strain 997 (type *C*) of the virus (10^6 *ID*50 on each monolayer of 2×10^6 cells). After 30 min. adsorption the sheets were washed, medium containing 0–6 μgm. proflavine per ml. added and the cultures incubated at 37° C. for 4 hr. The entire cultures were then either (*a*) treated with 0·1 per cent sodium dodecyl sulphate[7] to disrupt the cells and the released virus titrated in 7-day unweaned mice, or (*b*) treated with phenol[8] at 2° C. and the infective ribonucleic acid titrated in pig kidney cell monolayers. In view of the photodynamic action of proflavine on the virus of foot-and-mouth disease[9], all the experiments were carried out in the absence of light or in subdued lighting conditions. The results in Table 1 show that a marked inhibition of infective virus synthesis occurred when the medium above the infected monolayer contained proflavine. As little as 1 μgm. proflavine per ml. reduced the infective virus titre thirty-fold, whereas the infective ribonucleic acid titre was unaffected by this concentration. When the proflavine concentration was increased to 2 μgm./ml. the virus titre was reduced by a factor of one thousand but the ribonucleic acid titre was reduced only ten-fold. It is clear, therefore, that proflavine exerts a much greater effect on the formation of fully infective virus than it does on the synthesis of the infective ribonucleic acid.

Infected monolayers incubated in the presence of 2 μgm. proflavine per ml. showed cytopathogenic

Table 1. Effect of Proflavine on the Synthesis of Virus and Infective Ribonucleic Acid by Pig Kidney Cells Infected with Foot-and-Mouth Disease Virus

Proflavine (μgm./ml.)	Virus titre (log *ID*50/ml.)	Infective ribonucleic acid (log *ID*50/ml.)
0	6·8	2·7
0·5	6·3	—
1·0	5·3	2·6
1·5	4·4	1·7
2·0	3·8	1·5
3·0	3·8	0·4
4·0	3·3	Non-infective
6·0	2·8	Non-infective

changes similar to those seen in duplicate virus-infected cultures incubated in the absence of proflavine. Although these changes occurred more rapidly in the monolayers free from proflavine, with medium containing 2 μgm./ml. the cells were beginning to show cytopathogenic changes after 4 hr. and were completely off the glass after 24 hr. When the concentration of proflavine was increased to 10 μgm./ml., however, no change was apparent in 4 hr. although the cells had rounded and partly left the glass after 24 hr. Cell sheets which had not been infected with virus were unaffected by medium containing 10 μgm./ml. in 24 hr.

The action of proflavine in inhibiting the synthesis of infective virus is very rapid. The results in Table 2 show the effect of adding 2 μgm. proflavine per ml. to virus-infected monolayer cultures at various intervals after infection and then continuing the incubation so that each culture was incubated for a total of 4 hr. following infection. Virus synthesis was stopped almost immediately, as shown by the corresponding titres in columns 2 and 3 of Table 2.

Table 2. Effect of Proflavine on the Production of Infective Virus in Pig Kidney Cell Monolayers

Time after infection (hr.)	Virus titre at time of adding proflavine (log *ID*50/ml.)	Virus titre at 4 hr. (log *ID*50/ml.)
0·5	2·5	2·5
1·0	2·3	3·0
1·25	2·3	3·0
1·5	3·0	3·3
1·75	3·8	4·5
2·0	4·3	4·5
3·0	6·3	6·0

Although the culture fluids obtained 24 hr. following infection of pig kidney cell monolayers with virus fixed complement with the type-specific antiserum, the culture fluids obtained from similarly infected monolayers which had been incubated in the presence of 2 μgm. proflavine per ml. did not fix complement. This effect of proflavine must be on the virus-cell system, as the complement-fixing activity of virus suspensions was unaffected by treatment with the same concentration of proflavine. These experiments lead to the conclusion that at low concentrations proflavine can exert a differential inhibiting effect on the formation of viral protein, with the result that infective ribonucleic acid is still formed whereas the synthesis of infective virus is greatly inhibited.

We wish to thank Dr. I. A. Galloway for bringing to our notice the photodynamic action of proflavine on the virus and Mr. B. Cartwright for carrying out the complement-fixation tests.

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A Possible Explanation of the Formation of Long Platelets from Pulmonary Megakaryocytes

The purpose of this communication is to suggest a possible explanation of the formation of the elongated sausage-shaped, sometimes bizarre long platelets that are occasionally encountered in human blood smears. Since Bizzozero[1] first described the platelets as a distinct entity in 1882, much has been conjectured as to the source and mechanism of their formation. Before Wright[2] described the formation of blood platelets from bone marrow megakaryocytes in the marrow sinusoids in 1910, the thrombocytes were assumed to be formed from disintegration of erythrocytes and leucocytes. Howell and Donahue[3] unsuccessfully attempted to show by lung perfusion studies in 1937 that the thrombocytes were formed from megakaryocytes. The latter they believed originated in the lungs. More recently, Humphrey[4] has added chemical evidence to the hitherto purely morphological evidence that the platelets are derived from the megakaryocytes. But according to Wintrobe[5]: "The mechanism of production of platelets from the cytoplasm of megakaryocytes is by no means clear."

Unaware of the studies of Howell and Donahue, Sharnoff and Kim[6] recorded their observations on pulmonary megakaryocytes which appeared to

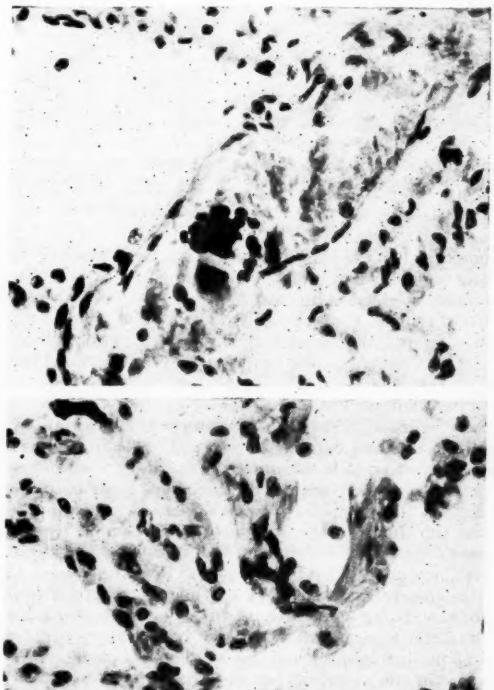

Fig. 1 (above). Megakaryocytes in human pulmonary pre-capillary blood vessel (× 414). Fig. 2 (below). Megakaryocyte dividing in the capillary anastomoses of the human lung. (× 414)
(*Photograph: Robert T. Duckworth*)

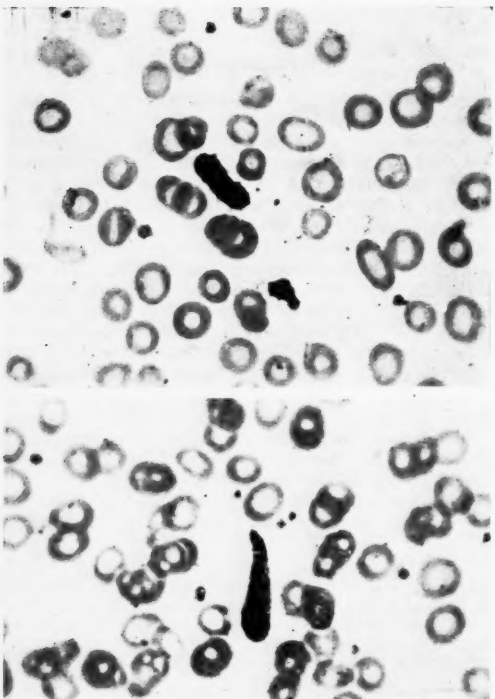

Fig. 3 (above). Sausage-shaped long human blood platelet (×830, oil immersion). Fig. 4 (below). Long human blood platelet (× 830, oil immersion)
(*Photograph : Robert T. Duckworth*)

indicate that the presence of these cells in mammalian lung vessels is a normal phenomenon, where they appear to break up into platelets. Their studies demonstrated that the cells seen in the lung vessels were identical histochemically and morphologically with the bone marrow megakaryocytes and that they were transported from the bone marrow to the lungs by the venous circulation. Their histological observations indicated that the megakaryocytes are too large to pass the lung capillaries intact (Fig. 1) and that the cells appeared to break up in the capillary anastomoses by the pumping action of the right heart ventricle (Fig. 2). The megakaryocytes appeared to be moulded into the shape of the capillaries and divided by their anastomoses. It was postulated that in assuming the capillary outline by being pressed into the vessels the cells can emerge as casts of the vessels, thus occasionally being encountered in blood smears as long platelets (Figs. 3 and 4). It can be further postulated that further break up of these elongated platelets may occur in the eventual passage through the peripheral capillary vascular system. It also would appear that the elongated forms are more commonly seen in individuals with high platelet counts where the platelets appeared freshly formed.

In summing up, it would appear that long platelets may be formed from pulmonary megakaryocytes by being pressed into the lung capillary blood vessels and emerge as casts of the same.

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A Seasonal Rhythm in the Presentation of Bone Sarcoma in Man

From a study of the ætiology of osteogenic sarcoma in man carried out during the past four years, it has been possible to demonstrate certain trends in the age and sex incidence of these relatively rare neoplasms[1,2]. Probably the most interesting features are the observations that the tumours tend to arise at an earlier age in females among adolescents, and also the higher incidence of tumours of the arm and pectoral girdle at an earlier age compared with those of the leg and pelvis in juveniles of both sexes. On comparison of the mean ages of groups of osteogenic sarcomata in adolescent males and females, whether for the whole skeleton or for individual bones, the differences of mean ages (male minus female) are seldom statistically significant, nevertheless they are almost invariably in the same direction.

The most likely explanation of these differences in age, sex and site would seem to lie in the relatively advanced skeletal growth of girls, and in the general cephalad-caudad sequence of growth progression. It is well known of course that the majority of osteogenic sarcomata of adolescents arise in the metaphyses of the major long bones, although this feature of consistent anatomical location is not so clearly defined in tumours of persons over the age of fifty-five years, among whom Paget's osteitis deformans forms the background of the majority of cases—at least in Great Britain[1]. In this older age-group the trends mentioned above cannot be shown to occur.

Among the characteristic patterns of juvenile bone growth is a seasonal rhythm with the maximum velocity peak in the spring months of April, May and June. The literature on this subject has been discussed by Brody[3] and by Tanner[4], the former author comparing the human growth-cycle with other photoperiodic phenomena of mammals and birds. In discussing this topic Tanner[4] states that the monthly height-gain average for the period April–June may be as much as 2–2½ times that of the months October–December.

In the light of these considerations an analysis was made of the case-histories of 102 osteogenic sarcomata included in the records of the Bristol Bone Tumour Register; and from among these were eventually separated a group of 40 tumours of long bones all in persons less than 30 years old. This small series was supplemented by the addition of a further 34 cases from four other hospitals, details being furnished by the consultant surgical staffs and medical records officers of these institutions. These 74 cases have been plotted in Fig. 1 according to the month when they

first complained of any definite symptom directly related to their subsequent clinically apparent tumour. This initial symptom was most often bone pain—less frequently pain and local swelling. The data are cumulative over a period of 18 years (1941–58). It will be noted that the incidence of tumours is greater during the months June–November inclusive, when the monthly average was 9·2 tumours per month, than for the months December–May, when the average of 3·2 tumours per month was encountered. (This difference is statistically significant : $\chi^2 = 16{\cdot}33$; $P < 0{\cdot}01$.)

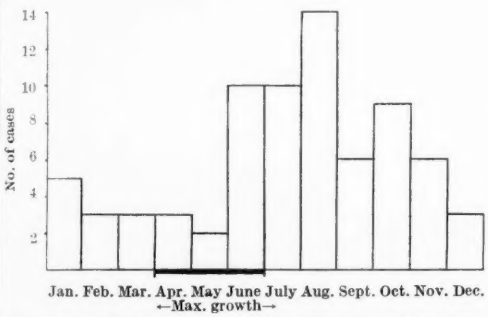

Fig. 1. Osteogenic sarcoma—long bone cases only, all less than 30 yr. old. Plotted according to month of presenting symptom : 'summer' period (June–November, inclusive), 55 cases ; 'winter' period (May–December, inclusive), 19 cases ; total, 74 cases

The same data were re-examined by annual groups (1943–58), but excluding 4 tumours which were recorded for the years 1941–42. Although the numbers each year are small, the trend of numerical preponderance in 'summer' still appears. The annual distributions are shown in Fig. 2. In 13 of 16 recorded years the number of tumours presenting during the 'summer' period is greater than that encountered for the corresponding 'winter' period. (These differences are again significant, $t = 3{\cdot}04$; $P < 0{\cdot}01$.)

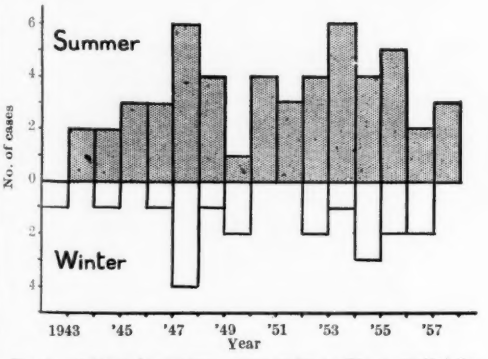

Fig. 2. Osteogenic sarcoma—same series as Fig. 1, plotted by years according to timing of presenting symptom. Comparing numbers in 'summer' and 'winter' periods the difference is statistically significant ($P < 0{\cdot}01$)

For brevity's sake it may simply be stated here that these differences in monthly incidence do not appear in a similar analysis of a series of 55 osteogenic arcomata in older persons more than thirty years of age. This negative result might be expected in view of the modified ætiology of bone tumours of this age-group.

It may be added that this increase in 'summer' incidence in the presentation of sarcomata holds for either sex when the whole series is so sub-divided. Moreover, it exists in each of the four major component groups of cases which were derived from Bristol, London, Manchester and Glasgow. (It has also appeared in a further group of 15 patients, details of whom were received too late for inclusion in the present study.)

With the material available it is not yet possible to define the shape of the 'summer' peak or its precise timing ; but in all probability it appears sometime during July and August, that is, about 3 months after the spring peak in the bone-growth velocity curve.

In adolescents the growth of bone in length with subsequent remodelling continues throughout the year, and is responsible in some obscure way for the basic monthly level of incidence of bone sarcoma. The probable size of the lag period between the two peaks of spring growth and presentation of bone sarcoma would seem however to suggest a biological linkage, especially in the light of collateral evidence which relates these two phenomena. Inquiry has not indicated any extraneous factors which might otherwise account for this abnormal distribution of tumour presentation during the yearly cycle.

Dr. Grace M. Jeffree has assisted in this work by examining the case records of the Bristol group, and Mr. G. M. Clarke has given invaluable advice with the statistical treatment of the material.

Details of patients have been freely given by the contributing members of the Bristol Bone Tumour Registry : by Mr. H. Jackson Burrows, and the Medical Records Officer and Committee of the Royal National Orthopaedic Hospital, London : by Dr. Ralston Patterson, of the Christie Hospital and Holt Radium Institute, Manchester : by Mr. Rowland Barnes, and Dr. Mary Catto, of the Glasgow Western Infirmary : and by Dr. Constance A. P. Wood, of the Hammersmith Hospital, London.

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PLANT PATHOLOGY

Needle Transmission of a New Maize Virus

The rough dwarf disease of maize ("Nanismo Ruvido del Mais") has been known from Italy since 1949 [1] and has lately been reported from Israel too[2]. The symptoms of the disease and its epidemiology were described in both countries[3,4] with the assumption that the causal agent is a plant virus. Since no experimental transmission of the disease had been accomplished, it was not certain that the agent was a virus. All attempts to transmit the disease by rubbing sap into maize leaf blades, using various abrasives, have failed. Transmission trials with a local dodder species, *Cuscuta eigii* Sroëlov, also proved negative.

Recently, however, transmission has been achieved for the first time by the following method. Hybrid maize plants showing severe dwarf symptoms were ground in a meat mincer, the sap squeezed through a cheese cloth and then centrifuged for 5 min. at 3,000 r.p.m. The supernatant fluid was injected by means of a 1 c.c. tuberculin syringe into the stalks of 3-week-old hybrid maize seedlings (Neve Yaar hybrid 22, single cross) grown under insect-proof conditions. The dosage was about 0·2 c.c. per seedling divided into 5 punctures at different sites. A control series was injected with healthy sap in the same manner. Three out of twelve plants injected with diseased sap, in two different series, developed both stem and leaf symptoms (including the rare symptom of split blade) within two months. As this was done in winter, without artificial illumination, it is believed that during summer the development of symptoms should be faster. Infectivity of the sap, when frozen, was retained for at least 24 hr. Since the virus is not transmitted by seed, the reliability of the test seedlings is unquestionable.

Similar cases where mechanical transmission of plant viruses could be obtained by needle inoculation only are those of sugar beet curly top[5] and clover wound tumour[6]. Both these viruses are leaf hopper-borne and, at least in the case of curly top, the virus is believed to exist in the phloem which might be considered inaccessible to ordinary surface rubbing[7]. In the case of the maize rough dwarf virus it may be inferred from Biraghi's studies[8] on the pathological anatomy of the disease that the virus tends to inhabit the phloem, though its natural vector is still unknown.

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BIOLOGY

Black Marlin in British East African Waters

Recently I stated that only the striped marlin (*M. audax*) had been caught by the East African Marine Fisheries Research Organization, and records of the black marlin in these waters were of doubtful value[1].

Since that communication I have taken two black marlin while using a longline 10 miles off the Tanganyika coast at latitude 8° S.; the fish were of standard length 2,130 and 2,325 mm. and weight 125 and 135 lb. respectively. On capture and comparison the differences from the striped marlin were most obvious—a very low dorsal fin, deep body, steeper head profile and 'rigid' pectoral fins. Proportional measurements confirmed the field observations and an examination of the morphology of the pectoral girdle showed it to be similar to that described by Morrow[2] as diagnostic for the black marlin. Colour was as follows: in life, upper two-thirds of body and fins blue-grey and lower third of body white, the join between the two colours being distinct; on death, the colour fades rapidly and the body and fins become grey, a little darker above. There are at no time any signs of the vertical stripes or brilliant cobalt blue coloration of the striped marlin.

Morrow (personal communication) reveals that his Pemba specimen of marlin weighed 159 lb. at 2,151 mm. and *not* 259 lb., as reported in his paper on East African fishes[3], and thus the record is validated as that of a black marlin.

In a recent paper on marlin taxonomy, Morrow[4] examined the pectoral girdle of the remains of Playfair's type specimen of *H. brevirostris* from Zanzibar and found it to correspond exactly to that of the black marlin[2]. Thus the position of this fish is clarified, the original proportional measurements and later examinations of the type specimen being insufficient for exact identification as stated earlier[1].

The black marlin is rare in this area, only two having been caught hitherto by this Organization, as compared with eighty-four striped marlin.

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A Chimæric Duck with the Head of a Chick

It is well known that the chick embryo fails to produce detectable antibodies against various foreign antigens, so providing a favourable environment for culturing viruses and transplanting various tissues of

Fig. 1. A duck embryo with the grafted head of a chick, after 28 days of incubation

Fig. 2. X-ray photographs of the skulls at hatching. Left, a duck; centre, the chimæra (Fig. 1); right, a chick. Note the striking similarity between the duck and the chimæra, except the upper beaks

birds and mammals[1]. It is also known from the work of Billingham *et al.*[2] that "actively acquired tolerance", the power to react immunologically against foreign homologous tissue cells with which they have been inoculated in fœtal life, is never developed by birds and mammals, or developed only to a limited degree. A renewed interest in heterotransplantation stimulated us to graft various types of tissue primordia between embryos of two different genera of birds, the chick (Galliformes) and the duck (Anseres). Using the same combination, Hašek and his co-workers were not successful in inducing a tolerance for skin heterografts between young obtained by embryonic parabiosis[3] or between young injected with each other's spleen or bone marrow cells shortly after hatching[4]. On the other hand, some cases of limb bud grafting during early days of incubation by Eastlick[5] seem to indicate a certain degree of tolerance, although his experiment was carried out from a point of view of tissue incompatibility in heterologous combination[6].

As one of an experimental series of reciprocal chick–duck heterotransplantation, the grafting of the forebrain region following the technique originally developed by Martinovitch on the chick embryos[7] was performed. The heads were severed just behind the optic vesicle, and were exchanged between the embryos of white duck and a coloured breed of chick, Barred Plymouth Rock, at stages corresponding to Hamburger and Hamilton's stage 10–11. These stages were reached by the chick after about 42 hr., and by the duck after about 55 hr. of incubation at 37·5° C. While the chick embryos grafted with duck heads did not survive for long, one of the duck embryos with the head of a chick survived through the whole length of its embryonic life, 28 days of incubation (26 days after grafting). Fig. 1 illustrates this chimæric embryo.

In size and in growth of feathers, the chimæra resembles the average duck embryo at hatching. However, the umbilical ring was still large and the withdrawal of the yolk into the body cavity had not begun. The host duck was found by examining the gonad to be a male. The contribution made by the graft was represented by the upper beak and eyes, the under-developed crest and the melanophores. The latter spread over both lateral surfaces of the head far caudad beyond the auditory opening, leaving unpigmented only the feathers on a mesial portion in the occipital region. It was clear that an extensive migration of the chick melanoblasts had taken place because the ear region is obviously of duck origin. At the top of the head, there was a round area where no feathers and melanophores were present. The cause of this is not clear. When an X-ray photograph of the skull of the chimæric embryo was compared with those of normal duck and chick embryos at hatching (Fig. 2), it proved to resemble the former much more than the latter. This indicates that skull of the chimæra was derived mainly from duck head mesenchyme.

While this grafting was being undertaken, Martinovitch published the results of grafting by the same method and combination[8] in which considerable abnormalities were reported. Our efforts to hatch these chimæras have been unsuccessful, and the prospect is rather dubious (Martinovitch, P. N., personal communication). However, a greater possibility of survival could be expected in the combinations of genetically more closely related species.

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The Benthos of Soft Sea-bottom in Arctic North America

Quantitative surveys of the benthos of soft sea-bottom were made in Baffin Island, N.W.T., during 1954 and 1955, in Greenland during 1956, and in Foxe Basin, N.W.T., during 1957, as part of expeditions organized by the Arctic Institute of North America and the Fisheries Research Board of Canada. These surveys, and others made previously in Greenland, show that *Macoma calcarea* communities[1] with standing crops generally greater than 200 gm./m.^{2} (fresh weight) occur in shallow water to about 50 m. depth in many localities in arctic North America. Other communities, some with very small crops, also occur in shallow water under localized, special conditions. They are the *Venus fluctuosa*, *Portlandia arctica* and *Chiridothea sabini* communities. The soft-bottom benthos in water deeper than about 50 m. forms at least two communities, the Foraminifera and *Arca-Astarte crenata* communities, with standing crops generally less than 100 gm./m^2.

The distribution of these communities can be related to the environmental conditions. In these arctic regions the water at depths greater than 50 m. has permanently low temperatures, which may either be just above 0° C. or below. Ekman[2] calls regions with such temperatures "low-arctic" and "high-arctic" respectively. However, overlying the deep water is an annually insolated layer, the temperatures of which may occasionally rise to 5° C. or more in summer. Low-arctic conditions can, and often do,

occur temporarily at the surface over high-arctic deeper water. The two terms can apply to temperature zones arranged vertically in the sea, as well as zoogeographical regions. As such they are convenient for an ecologist to use, but their significance is mainly as a guide to the temperatures; they imply nothing about the dynamics of the oceanographic conditions, unlike other systems of naming the arctic marine regions[3].

The *Macoma calcarea* communities have only been found where sea temperatures are permanently or seasonally low-arctic. Thus they occur in surface insolated water in the regions farthest north, but may extend deeper elsewhere, for example, Spitsbergen, Iceland[1]. They have a wide geographical range, apparently because some of the component species can adapt their breeding season to the time of year when appropriate temperatures occur, namely, in summer in the Arctic, in winter in warmer areas. The *Venus fluctuosa* and the *Portlandia arctica* communities appear to be restricted to certain bottom sediments within the low-arctic environment: types of coarse sand and fine mud, respectively. The *Chiridothea sabini* communities have only been found in two localities, in which the most obvious common environmental factor is very low summer temperature, that is to say, permanently high-arctic. The two deeper water communities occur below the depths affected by insolation where temperatures may be either low- or high-arctic.

Scattered dredge collections from Greenland to Alaska suggest that communities of *Macoma calcarea* are very widely spread in shallow water throughout arctic North America, but are replaced by other communities in deeper water. This pattern of vertical zonation appears to be very common.

An account of the collections and a more detailed discussion of the ecological and zoogeographical concepts mentioned here is being prepared for publication. Tables listing the species collected, and their numbers and weights per grab haul, are included in a doctoral thesis[4] deposited in the Redpath Library, McGill University, Montreal.

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CYTOLOGY

Nuclear Deoxyribonucleic Acid Content and Endopolyploidy in the Meristem of Onion Roots

Photometric analysis of the deoxyribonucleic acid content of nuclei would afford an interesting approach to the problems connected with polyploidy, polyteny and endomitosis, our knowledge of which is still fragmentary. It would also help us to understand the evolutionary processes and trace the relationships of species. If, in accordance with the hypothesis of deoxyribonucleic acid constancy, there is a strict correlation between the deoxyribonucleic acid content and the number of chromosomes, or more exactly the number of chromonemata, measurement of deoxyribonucleic acid would be the easiest way of studying polyploidy, polyteny and endomitosis, particularly in the interphase or prophase nuclei where the chromosome numbers cannot be counted. Evolutionary processes involving polyploidization from one species to another close one can be traced by means of photometric analysis, as the deoxyribonucleic acid content of the sperm or of the normal diploid nucleus appears to be characteristic of a species. The utilization of deoxyribonucleic acid content in problems of evolution is well illustrated by Hughes-Schrader's[1] work on a number of closely related species of mantids the karyotypes of which are not analysable by the usual methods of comparative cytology. The deoxyribonucleic acid content of the spermatids of two species, one having twice the number of chromosomes as the other, was the same, agreeing well with cytological studies which led to the conclusion that redistribution of chromosomal material rather than polyploidy was involved in the evolution of these species. On the other hand, in two other close species the deoxyribonucleic acid ratio of the spermatids was very near 1 : 2, indicating that polyploidy had played a part in their evolution.

During the course of studies on the deoxyribonucleic acid content of nuclei in the meristem of onion roots[6] in one of the central rows of cells which later become central vessels an unusual prophase was found in one of the roots. Each of its chromosomes showed very distinctly two relationally coiled strands. In these sections of roots fixed in acetic acid/alcohol (1 : 3) pairs of sister chromatids at prophase usually appear as single strands. Each strand in this exceptional prophase, furthermore, corresponded in thickness to a whole chromosome of a normal mid-prophase, and the former can be identified as a mid-prophase by the length and relic coiling of the chromosomes. No doubt this nucleus has a diploid complement of chromosomes with four, instead of two, chromatids each. Judged by the number of genomes, such a nucleus is essentially tetraploid. This prophase nucleus happened to be completely, or practically completely, within the section (15μ thick) in spite of its large volume of 3,638μ^3 (as compared with 903–1,004μ^3 found in diploid mid-prophases). (The volume in μ^3 was computed as $V = 2hA/3$ where A is area in μ^2 of the largest cross-section of the nucleus measured by a planimeter from a camera lucida drawing, and h is height in μ found as the average difference of four pairs of readings from the microscope fine-adjustment screw.) The deoxyribonucleic acid content measured in arbitrary units, according to the two wave-length method of Patau[3] with modifications[6] was $\gamma = 46{\cdot}34$, almost exactly twice the mean obtained from seven diploid prophase nuclei ($\bar{\gamma} = 22{\cdot}88 \pm 0{\cdot}44$) which is here taken as the best estimate of $4C$.

Similar tetraploid prophases have, of course, been observed before in differentiated root tissue (for example, in great numbers in *Rhoeo* roots treated with indoleacetic acid[2]). What makes the present nucleus highly unusual is its location well within the meristematic part of the root. It is, however, a region in which the cells of the central rows do not ordinarily divide any more; instead, many or most of the nuclei in these rows step up their deoxyribonucleic acid content to what must be about $8C$ or more as judged by their striking combination of large size and intense staining. One of these was measured.

The value obtained, $\gamma = 41 \cdot 35$, is somewhat less than $8C$. It probably had not finished synthesizing deoxyribonucleic acid. In sections of 15μ most of these nuclei are cut, so that when choosing the nucleus to be measured selection for small volume was inevitable. This nucleus was $1,534\mu^3$, much less than the volume of the tetraploid prophase nucleus and almost the same as the volume, $1,569\mu^3$, of a $4C$ interphase nucleus ($\gamma = 22 \cdot 87$) which was also found in a central cell row. A volume of $1,534\mu^3$ falls well outside the range of interphase nuclei of the diploid mitotic cycle. Lying in a central cell row this nucleus may have been approaching another deoxyribonucleic acid synthesis. In that event it would be more proper to call the nucleus a tetraploid interphase I rather than a diploid interphase III. (During deoxyribonucleic acid synthesis an interphase I with the deoxyribonucleic acid content $2C$ is followed by an interphase II with intermediate deoxyribonucleic acid content, and this by an interphase III with deoxyribonucleic acid content $4C$.) The ambiguity of interpreting deoxyribonucleic acid classes in terms of polyploidy has already been stressed by Patau and Swift[5]. What can presumably safely be said in the case, say, of an $8C$ interphase is that such a nucleus must be at least a tetraploid and no more than octoploid. In central cell rows within the meristem, though in its proximal part, the nuclear deoxyribonucleic acid content is occasionally stepped up still further. These nuclei are usually too large to be included in one section. The two cut parts (identified by their position relative to eight surrounding nuclei which were also cut) of one such nucleus in neighbouring sections were measured separately. The total deoxyribonucleic acid content $\gamma = 81 \cdot 56$ is 11 per cent less than $16C$. The difference could again be plausibly ascribed to uncompleted deoxyribonucleic acid synthesis, as the volume, $4,575\mu^3$, of this interphase nucleus was not much more than that of the $8C$ prophase.

It is noteworthy that the appearance of deoxyribonucleic acid values higher than $4C$ in the central cell row is accompanied by an almost complete disappearance of mitotic nuclei. The tetraploid prophase was the only exception observed. All other nuclei were clearly at interphase. In these cells, contrary to those of the surrounding tissue, the initiation of mitosis has been blocked, but deoxyribonucleic acid synthesis has not. Precisely the opposite situation was found by Patau[4] in the corresponding cell rows of *Rhoeo*. In these, mitotic activity also stops long before it ends in the surrounding tissue, but deoxyribonucleic acid synthesis is blocked even earlier, for, in these rows (not only in the proximal meristem but also in the elongation zone) all but a very few nuclei have the deoxyribonucleic acid content $2C$. This means that the great majority of nuclei after their last deoxyribonucleic acid synthesis still underwent a mitosis, as this is presumably the only process capable of halving the deoxyribonucleic acid content. The fact that either of the two processes—deoxyribonucleic acid synthesis and mitosis—may be blocked first characterizes them as essentially independent of each other, even though a normal mitosis presupposes a previous deoxyribonucleic acid synthesis.

It is concluded that in central cell rows of onion roots, mitotic activity ceases deep in the meristem. Instead, endopolyploidy develops, with the deoxyribonucleic acid content going up to $8C$ or even $16C$. One quite exceptional prophase was found in a central cell row in the meristem that presumably had the diploid number of chromosomes, with four instead of two chromatids. Its deoxyribonucleic acid content was $8C$.

This investigation was supported by grants to the late Dr. C. Leonard Huskins from the American Cancer Society upon recommendation of the National Research Council Committee on Growth, from the Rockefeller Foundation and from the Research Committee of the Graduate School, University of Wisconsin, with funds supplied by the Wisconsin Alumni Research Foundation. My thanks are due to Dr. K. Patau for guidance.

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A Partial Chemical Characterization of Maize Coleoptile Cell Walls prepared with the Aid of a Continually Renewable Filter

The present work was undertaken with the objective (*a*) of preparing plant cell-wall fragments free of contamination by intact cells, cytoplasm, plastids and other cell inclusions, but containing most of the constituents of the cell wall, including proteins, and (*b*) of characterizing such a cell-wall fraction chemically. The procedure differed from those previously reported in that a filtration technique was employed for purification of the cell-wall fragments and in that isolation was accomplished in an essentially non-aqueous media. It is believed that the filtration technique may prove generally useful in the preparation of cellular components where purification by differential or gradient centrifugation proves impossible. Previous reports of the chemical composition of plant cell-wall tissue have been based on the residue remaining after extraction of tissue macerates with water[1]. Such residues undoubtedly contain particulate cellular inclusions.

Maize (*Zea mays*) coleoptiles were chosen for the present study because of the information already available regarding coleoptile tissue. The coleoptiles were excised from 5-day-old seedlings of Michigan 350 hybrid maize which had been germinated at 25° C. and 90 per cent relative humidity. 25 gm. of the coleoptile tissue were homogenized (Servall 'Omnimixer') for 10 min. at 16,000 r.p.m. together with 180 ml. of glycerol and 37 gm. of glass beads 200μ in diameter (Minnesota Mining and Manufacturing Company, Saint Paul, Minnesota). The homogenate so obtained was permitted to stand for ½ hr. during which time the bulk of the beads settled out. The supernatant fluid (Fig. 1*A*) was decanted into a 150-ml. coarse-porosity sintered glass funnel containing a filter-bed consisting of 1 cm. of the 200-μ glass beads. Filtration was accomplished at the suction pump with continual stirring at gradually increasing depth in the glass-bead filter so as to prevent mat formation. Plastids, nuclei, mitochondria and soluble protein appeared in the filtrate while the cell walls remained in the glass-bead filter-

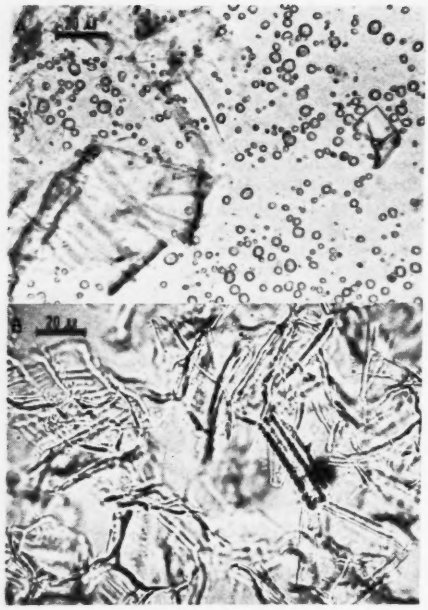

Fig. 1. Photomicrographs of cell-wall preparations at two stages of purification: *A*, crude homogenate showing cell-wall fragments and plastids; *B*, purified cell-wall fragments after fourth filtration

mat. The beads together with cell-wall material were resuspended in 50 ml. of glycerol and the mixture again allowed to settle for ½ hr. The supernatant fluid containing the suspended cell walls was again decanted into a fresh glass-bead funnel and the filtration and settling procedure repeated three times. After the last resuspension, the beads were again allowed to settle and the traces of beads remaining removed by centrifugation for 5 min. at 500*g*. The cell-wall material was then collected as a pellet by centrifugation at 25,000*g* for ½ hr. Purified cell-wall preparations so obtained constitute about 5 per cent of the initial dry weight of the corn coleoptile tissue and are practically free of microscopically visible and histochemically detectable cell inclusions as shown in Fig. 1*B*. If the filtration fluids are reworked until all visible cell-wall fragments have been removed, a yield of 20 per cent of the coleoptile dry weight is obtained. For chemical analysis, the cell-wall material was washed free of glycerol by suspension and resedimentation five times in a ten-fold volume of absolute alcohol and dried to constant weight.

The results of analysis of cell-wall preparations and of whole dried coleoptile tissue are presented and compared with those of other authors in Table 1. To our knowledge, no previous reports of the sulphur, calcium or magnesium contents of primary cell-wall tissue have been published. In general our results are in accord with previously published values with the notable exception of the protein content of the cell walls. Thimann and Bonner reported 12 per cent protein for *Avena* coleoptile (corresponding to 1·9 per cent nitrogen) while Nakamura and Hess reported 30·4 per cent protein for a water-insoluble fraction of maize coleoptile. In the present work, protein, calculated from the nitrogen determinations, would be 2·5–5·1 per cent. Probably the higher values previously reported are due to a greater degree of

Table 1. Composition of Coleoptile and Cell-Wall Preparation of Coleoptile of *Zea* and *Avena**

	Whole coleoptile (per cent dry weight)	Coleoptile cell-wall (per cent dry weight)
Ash	4·1, 4·4†	0·6, 1·3†
C	—	45
H	—	7
N	4·1	0·4–0·8, 4·9‡
P	0·8	0·03, 0·06‡
S	0·25	0·07
Ca	0·05	0·06
Mg	0·15	0·07
Protein	25·5, 15·2†, 3·1§	2·5–5·1, 30·4‡, 12§, 9·5¶
Cellulose	14·2, 13·2†, 10·1‡, 11·9§	27·4, 32·7†, 42§, 24·8¶
Pectin	4·0†, 2·3§	8·4, 10·2†, 8§, 0·3¶
Lignin	6·6	5·4
Ribonucleic acid	Less than 0·9	Less than 0·15

* We are indebted to Dr. Peter Albersheim for the anhydrouronic acid and to Mrs. Mary A. Vacasey for the calcium and magnesium determinations.
† Maize coleoptile (ref. 1*c*).
‡ Maize coleoptile (ref. 1*b*).
§ *Avena* coleoptile (ref. 1*a*).
¶ *Avena* coleoptile (ref. 5).

contamination of the cell-wall preparation by cytoplasmic substances.

A limited characterization of the polysaccharide components of the cell wall was made by the general procedure of Norman[2]. Cellulose was extracted from the 0·5 per cent ammonium oxalate insoluble cell-wall fraction with 72 per cent sulphuric acid after hydrolysis with 2 *N* hydrochloric acid. The extract was diluted to 5 per cent sulphuric acid, hydrolysed, and glucose was determined with the aid of glucose oxidase. By this procedure the cellulose content was calculated to be 27 per cent. The 'pectin fraction' as isolated by the usual precipitation method from ammonium oxalate extracts constituted 28 per cent of the dry weight of the cell-wall preparation. Paper chromatographic examination of the 'pectin fraction' following exhaustive methylation and acid hydrolysis[3] indicated that only 2–5 per cent of the cell-wall weight was polyuronic acid. Since losses of uronic acid by this method might be expected, the value of 8 per cent obtained by Dr. Albersheim seems correct. The ribonucleic acid content of the cell wall was found to be less than 0·15 per cent as determined by the method of Ogur and Rosen[4]. This would account for approximately half the total cell-wall phosphorus.

In summary, our present analysis accounts for only approximately 45 per cent of the cell-wall dry weight. Qualitatively, it may be stated that starch and dextrines are absent but there are large amounts of pentose and hexose polysaccharides. Further studies of these as yet uncharacterized carbohydrate fractions and the enzymatic activities of cell-wall fragments are in progress.

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FORTHCOMING EVENTS

Sunday, September 6—Wednesday, September 9

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (at York).—Continuation of Annual Meeting.

Sunday, September 6

At 10.30 a.m.—(in York Minster)—Religious Service. Preacher: The Most Reverend the Lord Archbishop of York.

Monday, September 7

At 10 a.m.—Prof. O. M. B. Bulman, F.R.S.: "Recent Developments and Trends in Palæontology" (Presidential Address, Section C).

At 10 a.m.—Prof. Ian A. Richmond: "The Nature and Scope of Archæology" (Presidential Address, Section H).

At 10 a.m.—Prof. A. Hemingway: "Artificial Organs—Biological Applications" (Presidential Address, Section I).

At 8 p.m.—Sir William Hildred: "International Air Transport Problems" (Evening Discourse).

Thursday, September 10—Friday, September 11

SOCIETY OF INSTRUMENT TECHNOLOGY (at the Polytechnic, Regent Street, London, W.1), at 9.15 a.m. Thursday and 10 a.m. Friday—Education Conference.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (with an honours or special degree in psychology or equivalent) IN PSYCHOLOGY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (September 14).

LECTURER IN EDUCATION at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 20).

LECTURER (with a good honours degree in electrical engineering or physics, and industrial or research experience in light-current electrical engineering) IN ELECTRICAL ENGINEERING at Queen's College, Dundee (University of St. Andrews)—Joint Clerk to the University Court, Queen's College, Dundee (September 28).

ASSISTANT LECTURER IN SOCIAL ADMINISTRATION—The Registrar, The University, Manchester 13 (September 30).

LECTURER IN MATHEMATICS at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

LECTURER IN ZOOLOGY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

SENIOR LECTURER IN PHYSICS; a LECTURER IN PHYSICS, and a LECTURER IN SOCIOLOGY at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 30).

LECTURER IN GEOGRAPHY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 1).

CHAIR OF CHEMISTRY at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 5).

CHAIR OF PHYSICS in the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 15).

LECTURER or ASSISTANT LECTURER (with special qualifications in physical chemistry) IN CHEMISTRY—Secretary, The Royal College of Science and Technology, Glasgow.

MAP CURATOR IN THE DEPARTMENT OF GEOGRAPHY AND GEOLOGY—The Registrar, University College of Wales, Aberystwyth.

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